LECTURE 8
MIDTERM RECAP
CONCEPTS OF COST
COST IN THE SHORT RUN

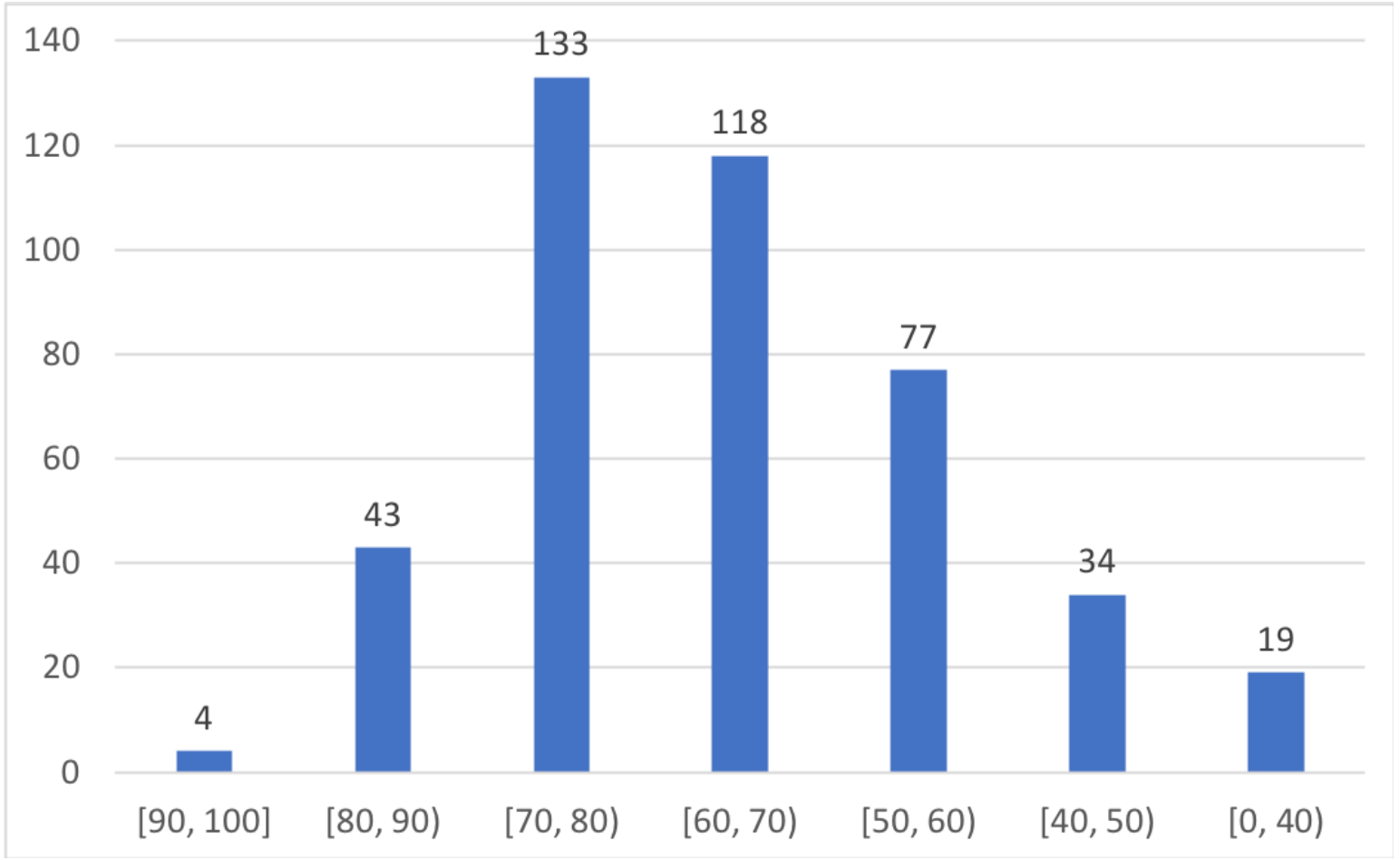
Part 1

Midterm Recap

Midterm Statistics

Median	67
Mean	65.1
Standard Deviation	13.2
Highest Score	100
75^{th} Percentile	74.6
25^{th} Percentile	58

Midterm Distribution



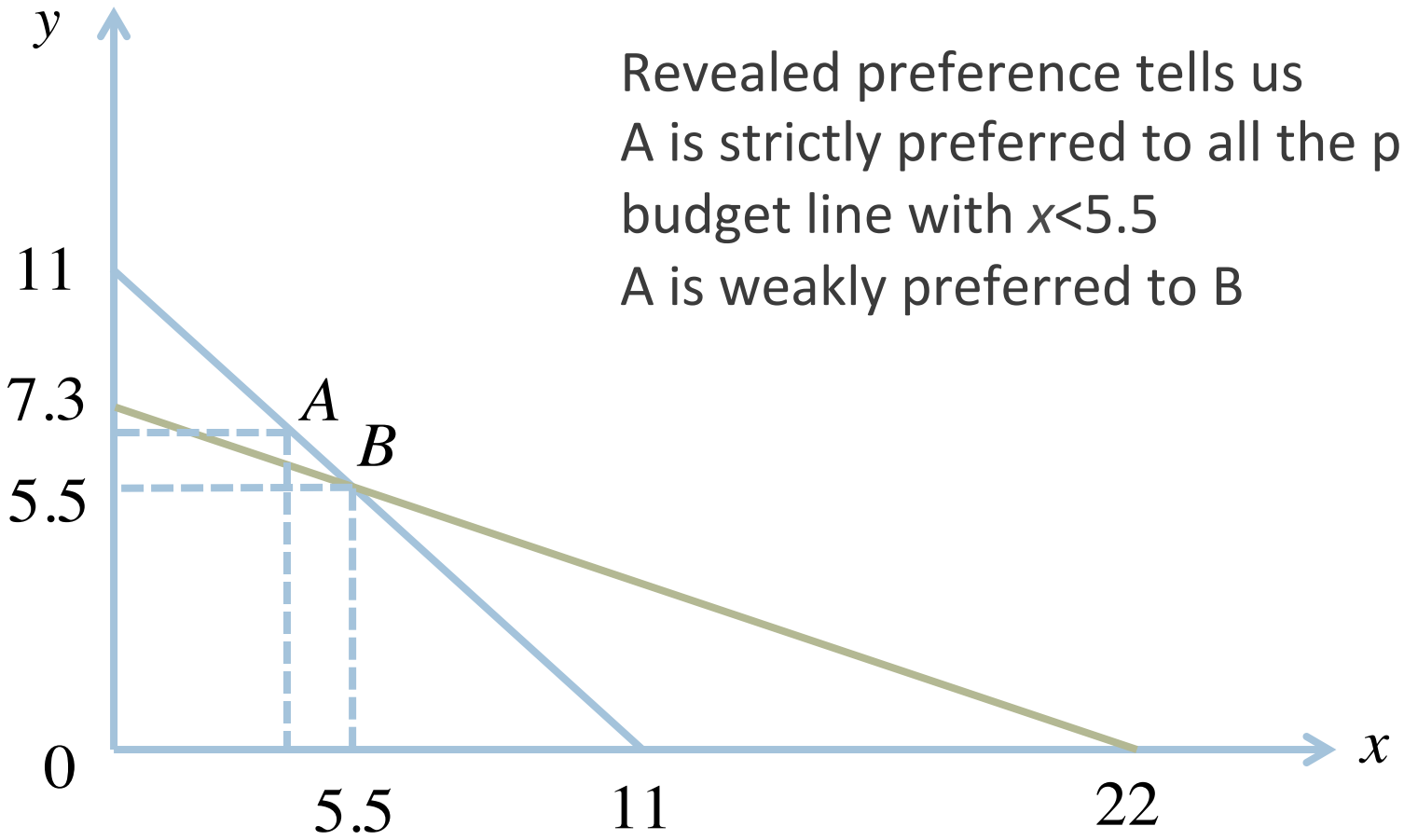
Midterm MCQ 1-4

- MCQ 1: budget line
  - More than half got it wrong
- MCQ 2: tangency condition
- MCQ 3: Engel curve, inferior good vs. Giffen good
- MCQ 4: Pareto efficiency vs. Pareto improvement
  - Practice Problems 4: question 1

Midterm MCQ 5

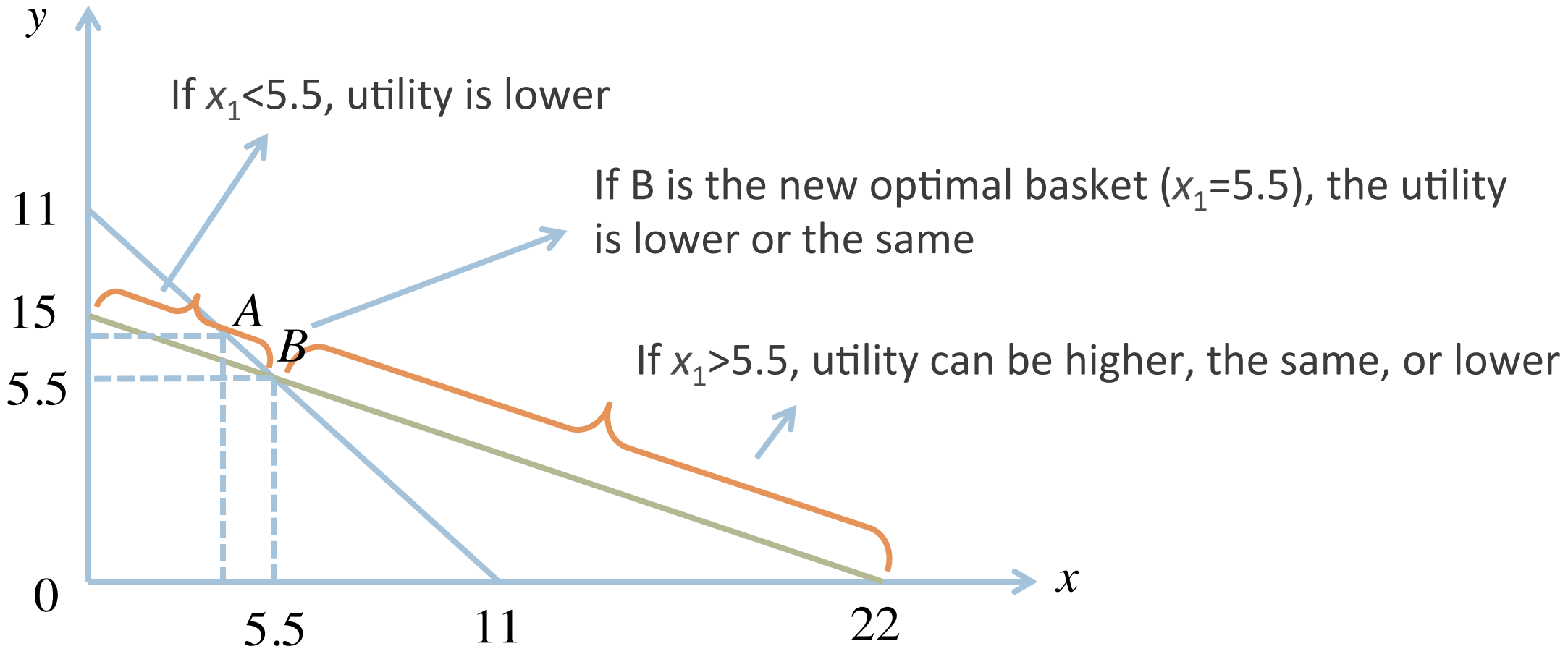
- Initially, price of *x* is \$2, price of *y* is \$2, income is \$22
  - Optimal basket is (4, 7)
- The price of *x* becomes \$1, price of *y* becomes \$3, income still \$22
  - There is a new optimal basket (x_1, y_1)
- The intersection point of the two budget lines
  - (5.5, 5.5)
- The original optimal basket lies above the new budget line
  - \$1*4+\$3*7=\$25>\$22

Midterm MCQ 5 Cont'



Revealed preference tells us
A is strictly preferred to all the points on the new budget line with $x<5.5$
A is weakly preferred to B

Midterm MCQ 5 Cont'



Midterm MCQ 5 Cont'

- A. If x_1=5.5, utility is still the same
  - It could be lower
- B. If x_1>5.5, utility is higher
  - It could be lower or the same
- C. If utility is lower, x_1<5.5
  - The correct statement is "if x_1<5.5, utility is lower"
- D. If utility is higher, x_1>5.5
  - Correct

Midterm MCQ 6

- Utility function is

$$U(x,y) = x^2 + y^2$$

  - Same as in homework 1 question 1
- Corner solution
- *X* is cheaper than *y*
  - The consumer only buys *x*
- When *x* becomes even cheaper
  - The consumer still only buys *x*

Midterm MCQ 6 Cont'

- The initial optimal basket is

$$x = \frac{I}{P_x}, y = 0$$

- The new optimal basket is

$$x = \frac{I}{aP_x}, y = 0$$

- Basket C (new price old utility) is the same as the initial optimal basket
- Basket D (old price new utility) is the same as the new optimal basket

Midterm MCQ 6 Cont'

- CV is

$$I - \frac{I}{P_x} \times aP_x = I - aI$$

- EV is

$$\frac{I}{aP_x} \times P_x - I = \frac{I}{a} - I$$

- Since EV=2CV,

$$\frac{I}{a} - I = 2(I - aI) \Rightarrow a = \frac{1}{2}$$

Midterm Structured Question 2 b)

- Utility function is

$$U(v,m) = 2\sqrt{v} + m$$

- Price of vegetables is \$2, price of meat is \$12, income is \$120
  - Initial optimal basket is v=36, m=4
- Suppose there is a \$50 spending limit on vegetables, what is the optimal basket?
  - NTUC Fair Price implemented this spending limit after DORSCON orange
- The spending constraint binds
  - The new optimal basket is v=25, m=5.83

Midterm Structured Question 2 c)

- What if we increase the price of vegetables so that the consumer spends $50 on vegetables?
  - The consumer buys less vegetables than in part b)
  - Since income is still $120, the consumer still spends $70 on meat
  - Since the price of meat is the same, the consumer buys the same amount of meat as in part b)
- General result: the consumer's utility is lower compared to the under the spending limit

Midterm Structured Question 2 b) and 2 c)

- What is the difference between the two?
  - Spending limit vs. higher price
- For consumers who initially spend more than $50 on vegetables
  - They spend $50 under both policies
  - Higher utility under spending limit
- For consumers who initially spend $50 or less on vegetables
  - Not affected by spending limit
  - Lower utility if the price of vegetables is higher

Midterm Structured Question 3 c)

- Dr. Zhang

$$U(h,s) = 4h + s$$

- Dr. Yang

$$U(h,s) = 3h + 2s$$

- Each has an income of $240 and gets a voucher of $40 on hot pot
- For each consumer
  - Either uses all income and voucher to buy hot pot
  - Or only uses the voucher to buy hot pot and uses all income to buy salad

Midterm Structured Question 3 c)

- Case 1: both only use the voucher to buy hot pot
- This is when

$$P_h > 4P_s$$

- The optimal basket for both is

$$h = \frac{40}{P_h}, s = \frac{240}{P_s}$$

- Dr. Yang always gets higher utility

$$U_{Zhang} = \frac{160}{P_h} + \frac{240}{P_s} < U_{Yang} = \frac{120}{P_h} + \frac{480}{P_s}$$

Midterm Structured Question 3 c) Cont'

- Case 2: Dr. Zhang uses the income and voucher to buy hot pot, Dr. Yang uses the income to buy salad and the voucher to buy hot pot
- This is when

$$\frac{3P_s}{2} < P_h < 4P_s$$

- Dr. Zhang's optimal basket and utility is

$$h = \frac{280}{P_h}, s = 0, U_{Zhang} = \frac{1120}{P_h}$$

- For Dr. Zhang to get higher utility, we need

Midterm Structured Question 3 c) Cont'

$$U_{Zhang} = \frac{1120}{P_h} > U_{Yang} = \frac{120}{P_h} + \frac{480}{P_s}$$

- Which means

$$P_h < \frac{25P_s}{12}$$

- Case 3: both only buy hot pot
- This happens when

$$P_h < \frac{3P_s}{2}$$

- Dr. Zhang always gets higher utility because of higher marginal utility of hot pot

Some Logistics

- Let me know if you have any questions regarding the midterm grading
- Final exam
  - Comprehensive but focuses on the materials after the midterm
  - Same type of questions and similar style
  - Fewer MCQs and more structured questions
- Change of homework groups
  - Allowed if it is a Pareto improvement
  - If there is any change to your group, inform your tutor by next week (week 10)

Part 2

Concepts of Cost

Opportunity Cost

- Opportunity cost is the cost associated with the best alternative that is not chosen
  - Suppose the firm has two alternative ways of using its capital, A and B
  - If the firm chooses A, the opportunity cost is the payoff the firm could have earned had it chosen B
- To determine opportunity cost
  - Ask "What does the firm/decision maker give up?"

Explicit vs. Implicit Costs

- Suppose you own and run a small software development firm
  - Wages to employees: $200,000
  - Rent: $50,000
  - Utilities and supplies: $60,000
- All the above are the *explicit costs* of running your own firm

u actly incurred this cost

- Your best alternative is to work for Google for $100,000 per year
- The $100,000 is an *implicit cost*

opportunity cost of your time when u run your own firm

didn't actly incur this cost, didn't pay anyone $100,000

Economic Costs

- Your opportunity cost of running your own firm is
  - 200,000+50,000+60,000+100,000=$410,000
- By running your own firm
  - You are incurring all the explicit costs can be avoided if u chose not to run your own firm
  - And forgoing the salary you could have earned if you chose the best alternative
- Economic costs
  - Are the same as opportunity costs
  - Include all explicit and implicit costs

From now on, whenever we talk abt cost, by default we mean economic cost.

Sunk Cost

- Sunk cost is cost that can never be recovered no matter what you do
  - Costs resulted from past decisions and cannot be avoided
  - No future decisions can change sunk costs
  - Sunk costs are irrelevant for future decisions
- To determine sunk cost
  - Ask "What costs *do not* vary across alternatives?"

you have to pay no matter what

since no matter what u do, u have to pay sunk cost, you should ignore sunk cost in your future decisions.

what is the cost I have to pay no matter what I choose to do?

Example: Leasing Expenditure

Suppose you own a retail chain. You are considering a temporary shut down of one the stores for a month. You do not own the property and you have to pay the rent no matter what.

Because rent is sunk cost, it shouldn't affect our decisions. So what decision should we make? open or shut down. If the firm wants to maximize profit, should shut down. Cos shut down, profit = -5000. If open, profit = -9000.
Because rent is sunk cost, we can just delete this column, no need to consider this column when considering to shut down or open.

	Revenue	Rent	Other costs
Stay open	$20,000	$5,000	$24,000
Shut down	0	$5,000	0

what is the cost I have to pay no matter what happens/what I choose? Rent is sunk cost.

Other costs vary across alternatives. If shut down, don't have to incur this cost. So this is not sunk cost.

In reality, when rent is low, e.g. $50, ppl will shut down (it's ok rent is low). But if rent=$5 million, many ppl will choose to open, coz they paid so much for rent, felt they will waste their money if not open. But actly as long as rent is sunk, it shouldn't matter how much rent is. They should make the same decision - shut down. In reality, many ppl make diff decisions based on how much sunk cost is. --> Sunk cost fallacy!

Example of Sunk Cost Fallacy: Driving in Singapore

- Do people drive more when they paid more for their cars?
- Sunk costs associated with buying a car in Singapore
  - COE (Certificate of Entitlement)
  - ARF (Additional Registration Fee)
- An increase in purchasing price (due to an increase in COE or ARF) by one standard deviation leads to an increase in driving by 9.48 km per month
  - Source: Ho, Png, and Reza (2017), *"Sunk Cost Fallacy in Driving the World's Costliest Cars"*.

If u buy a car today (paid for everything), tmr u change your mind, want to sell the car, cannot get the full COE back, part of the COE is sunnk immediately, and the rest of the COE will be sunk over time.

How much u drive your car shouldn't depend on how much u paid for COE. No matter what u do, drive a lot/little, not going to get COE back.

Part 3

Cost in the Short Run

Where are we?

- Production function
  - How firms turn L and K into Q
- Optimal choice of L and K
  - To produce a certain amount of output Q_0, how much L and K should the firm use?
  - How much does it cost to produce Q_0? if we do this for all possible levels of output, we can get cost curve.
  - Cost curve: cost as a function of Q
- 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

Short-Run vs. Long-Run in Production

- Suppose firm uses *L* and *K* to produce
- In the short-run
  - At least one input is fixed at a particular level
  - Usually we assume *K* is fixed
- In the long-run
  - Firm is free to adjust both inputs

Short-Run Total Cost

- Suppose

  w here is the economic cost of using each unit of labor
  r is the economic cost of using each unit of capital

  - price of labor is *w* per unit (w: wage)
  - price of capital is *r* per unit (r:rental rate)
- Suppose in the short run, capital is fixed at K_0
- Total cost in the short run is

$$STC = wL + rK_0$$

If I have a firm and I own this land, when I use the land for my production, I don't need to pay anything. -> It doesn't mean that it doesn't cost the firm any amt of money to use its own capital. There is a price the firm needs to pay coz opportunity cost. (if i don't use my land for my own production, can lease it out to other firm) (captured in r)

L here is not given, to calculate STC, the firm needs to figure out how much labor to use (optimal choice of labor).

How much labor should the firm use?

depends on firm's objective function

- Assume the firm maximizes profit
  - Profit=total revenue-total cost
- For any output level Q_0
- The firm chooses L to *minimize* the total cost of production

constrained minimization problem

Choosing labor so that I can produce Q0 units in the least expensive way. (minimize cost of production)

$$\min_{L} \quad wL + rK_0$$

$$s.t. \quad F(L, K_0) = Q_0$$

the firm needs to produce the target level Q0, e.g. 100 units this week

Only 1 unknown variable - L, K0 fixed

The constraint itself tells u how much labor u should use.

Example: Short-Run Labor Choice

- Suppose the production function is

$$Q = KL$$

- In the short run, capital is fixed at K=2
- If the firm wants to produce 4 units, the firm needs 4/2=2 units of labor
- For any output level Q, the amount of labor the firm needs is

L = Q / 2

Example: Short-Run Total Cost Curve

- Suppose w=2 and r=3
- If the firm wants to produce 4 units of output, its short-run total cost is

$$STC = wL + rK = 2 \times 2 + 3 \times 2 = 10$$

we can do this for any output level, not just output level 4 here.

- The firm's *short-run total cost curve* is

$$STC(Q) = wL + rK = 2L + 3K = 2(\frac{Q}{2}) + 6 = Q + 6$$

a relationship between total cost in the short run and Q (how much u are producing)

- Definition 8.1 *Short-run total cost curve* is short-run total cost as a function of Q
  - Holding w and r fixed not changing input prices.

In reality, input prices fluctuate. So we also want to know how total cost of production changes with input prices, not just Q.

Example: Short-Run Total Cost Function

- Suppose we do not know the values of *w* and *r*
- If the firm wants to produce 4 units of output, its short-run total cost is

$$STC = wL + rK = 2w + 2r$$

- The firm's *short-run total cost function* is

STC for any Q

$$STC(Q,w,r) = wL + rK = w(\frac{Q}{2}) + 2r$$

- Definition 8.2 *Short-run total cost function* is short-run total cost as a function of *Q*, *w*, and *r*

The difference between short-run total cost curve and short-run total cost function is similar to that between demand curve and demand function.

Variable Cost vs. Fixed Cost

total cost includes both variable cost and fixed cost.

- Definition 8.3 *Variable cost* (*VC*) coffee beans
  - Cost that varies as Q changes
  - When Q is 0, variable cost is 0 if not producing anything, then not incurring any variable cost.
- Definition 8.4 *Fixed cost* (*FC*) coffee machine
  - Cost that does not vary with Q as long as $Q>0$ as long as u are producing, fixed cost is nnot going to change with how much u produce.
- In the short run, for any $Q>0$
  - $STC(Q)=wL+rK_0=VC(Q)+FC$ labor is the input that is variable
  - Fixed cost=rK_0 capital is fixed in the short run

Fixed Cost vs. Sunk Cost

Is fixed cost always sunk cost? No.

fixed cost: as long as u are producing, have to pay for monthly rent.

- Suppose you rent a plant for production
  - The monthly rent is $10,000

fixed cost coz it doesn't matter how much u produce in your plant, gonna pay the same rent every month. But is this sunk cost? depends on whether u still need to pay it anot when u don't produce anything.

- Suppose you want to temporarily shut down the plant, i.e., produce Q=0
- Non-sunk fixed cost

when u are not producing anything, u don't have to pay $10,000. This other firm is paying for u.

  - If you can sublet the plant to another firm at $10,000 per month
  - The rent is not sunk

this $10,000 is avoidable when u don't produce anything, it's not sth u have to pay no matter what.

- Sunk fixed cost
  - If you cannot sublet
  - The rent is sunk

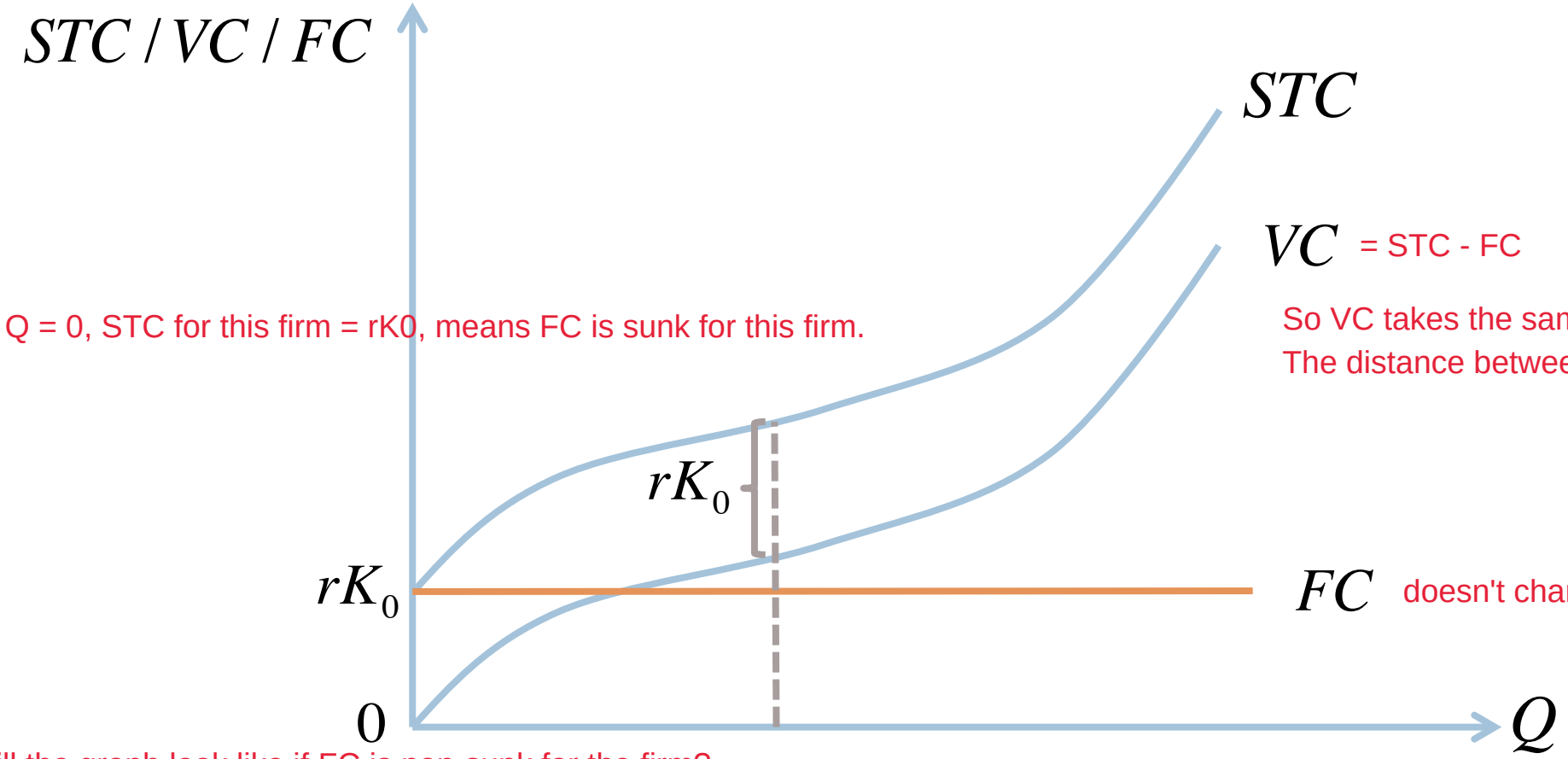
Fixed cost may or may not be sunk. Also possible if part of fixed cost is sunk and part is not sunk. e.g. u can sublet to another firm but it only pays $8000 per month, then non-sunk fixed cost = $8000. This is the amt u can avoid if u don't produce anything. Sunk fixed cost = $2000. Cannot avoid.

Sunk Cost and *STC* at *Q*=0

Whether the fixed cost is sunk or not only affects the total cost of production when u don't produce anything.
As long as Q>0 (producing), u have to pay fixed cost.
You may or may not need to pay your fixed cost when u don't produce anything.

- Recall short-run total cost curve
  - $STC(Q)=VC(Q)+FC$ when Q = 0, VC(Q) = 0 too.
- If FC is non-sunk, then when Q = 0, can avoid paying fixed cost.
  - $STC(0)=$ 0
- If FC is sunk, then
  - $STC(0)=$ FC
- If part of FC is sunk, then
  - $STC(0)$=the sunk part of FC

STC, VC, FC in Graph



When Q = 0, STC for this firm = rK0, means FC is sunk for this firm.

VC = STC - FC

So VC takes the same shape as STC.
The distance between the 2 is FC.

FC doesn't change with Q

How will the graph look like if FC is non-sunk for the firm?
Remember that whether the FC is sunk or not only affects STC at Q = 0. When FC is non-sunk, STC(0) = 0. Means there will be a discontinuity in the STC curve, there will be a jump in the total cost curve when Q > 0.

Short-Run Marginal Cost

- Definition 8.5 *Short-run marginal cost* measures the rate at which short-run total cost changes with output

$$SMC(Q) = \frac{dSTC(Q)}{dQ} = \frac{\Delta STC(Q)}{\Delta Q}$$

if increase Q by 1 extra small unit, how much does your total cost increase?

where ΔQ is extremely small

The total cost curve in the short run and the variable cost curve will always have the same slope! And that slope is the short-run marginal cost.

- Slope of the short-run total cost curve
- Slope of the short-run variable cost curve

FC is constant, just a number, not a function of Q.

$$SMC(Q) = \frac{dSTC(Q)}{dQ} = \frac{d(VC(Q)+FC)}{dQ} = \frac{dVC(Q)}{dQ}$$

Diminishing Marginal Return (of Labor) and Short-Run Marginal Cost

- Rewriting short-run marginal cost

$$SMC = \frac{\Delta VC}{\Delta Q} = \frac{w\Delta L}{\Delta Q} = \frac{w}{MP_L}$$

MPL = dQ / dL

Inverse relationship between SMC and MPL.
When MPL higher, SMC is lower.

- Recall diminishing marginal returns
  - MP_L decreases as L increases
- If we have diminishing marginal returns (assuming marginal product of labor is positive) then

if it's -ve, u won't use labor to that point.

Similarly, if u have increasing marginal returns, SMC will be downward sloping.

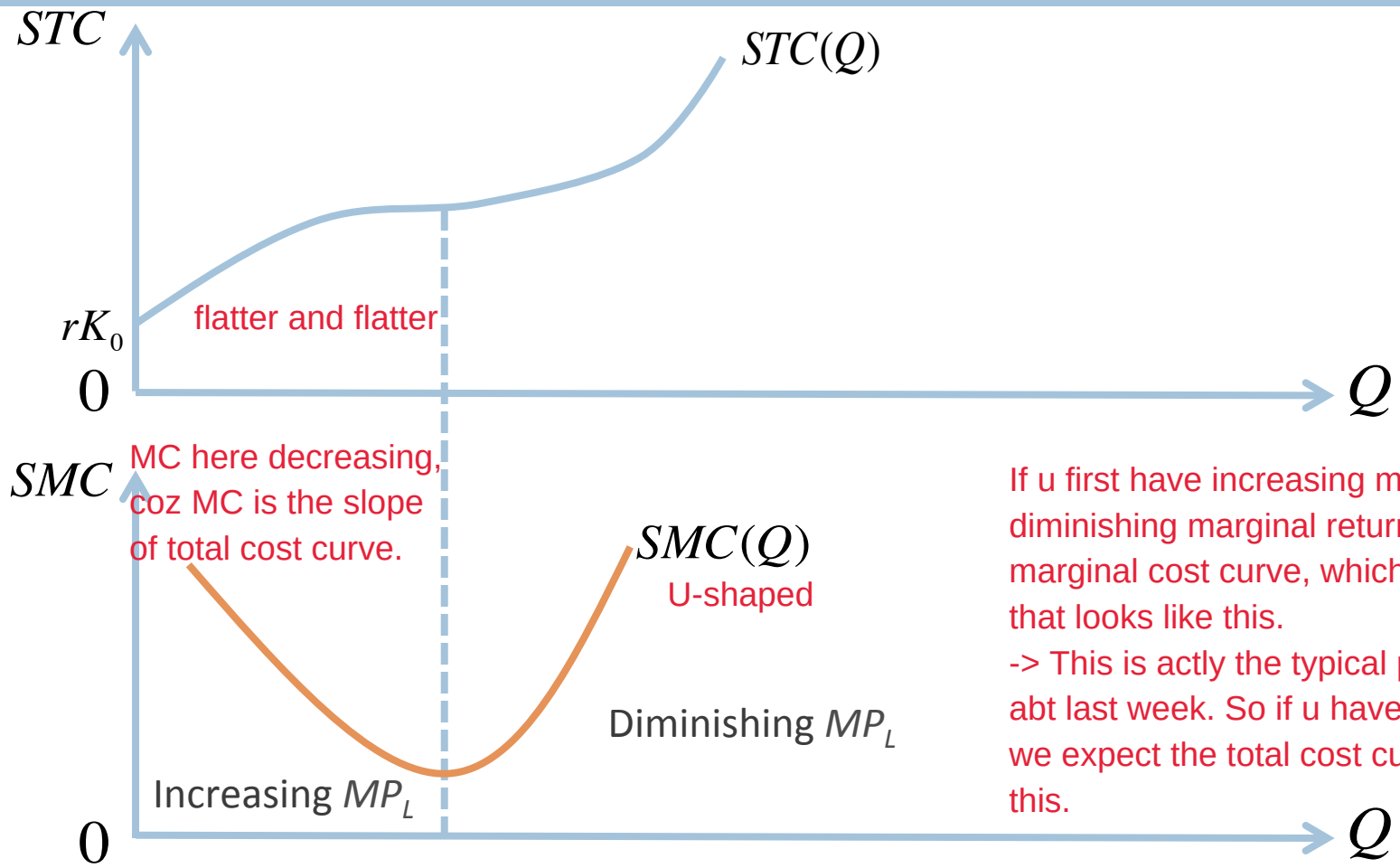
  - SMC increases as Q increases -> marginal cost curve in the short run is upward sloping

When Q increases (want to produce more), how can u do this in the short run? cannot change amt of capital in short run, the only thing u can do is to use more labor. So as Q increases, L increases. If the firm has diminishing marginal returns, MPL decreases. So SMC will increase.

doesn't mean all total cost and marginal cost curves look like this, depending on production function.

Typical Short-Run Total and Marginal Cost Curves

correspond to the typical production process we learnt last week.



If u first have increasing marginal returns and then diminishing marginal returns, u will have a U-shaped marginal cost curve, which will give us a total cost curve that looks like this.
-> This is actly the typical production process we talked abt last week. So if u have a typical production process, we expect the total cost curve in the short run to look like this.

Short-Run Average Costs

- Definition 8.6 *Short-run average total cost (SAC)*

$$SAC(Q) = \frac{STC(Q)}{Q}$$

on average, how much does it cost u to produce each unit.

- Definition 8.7 *Average variable cost (AVC)*

$$AVC(Q) = \frac{VC(Q)}{Q}$$

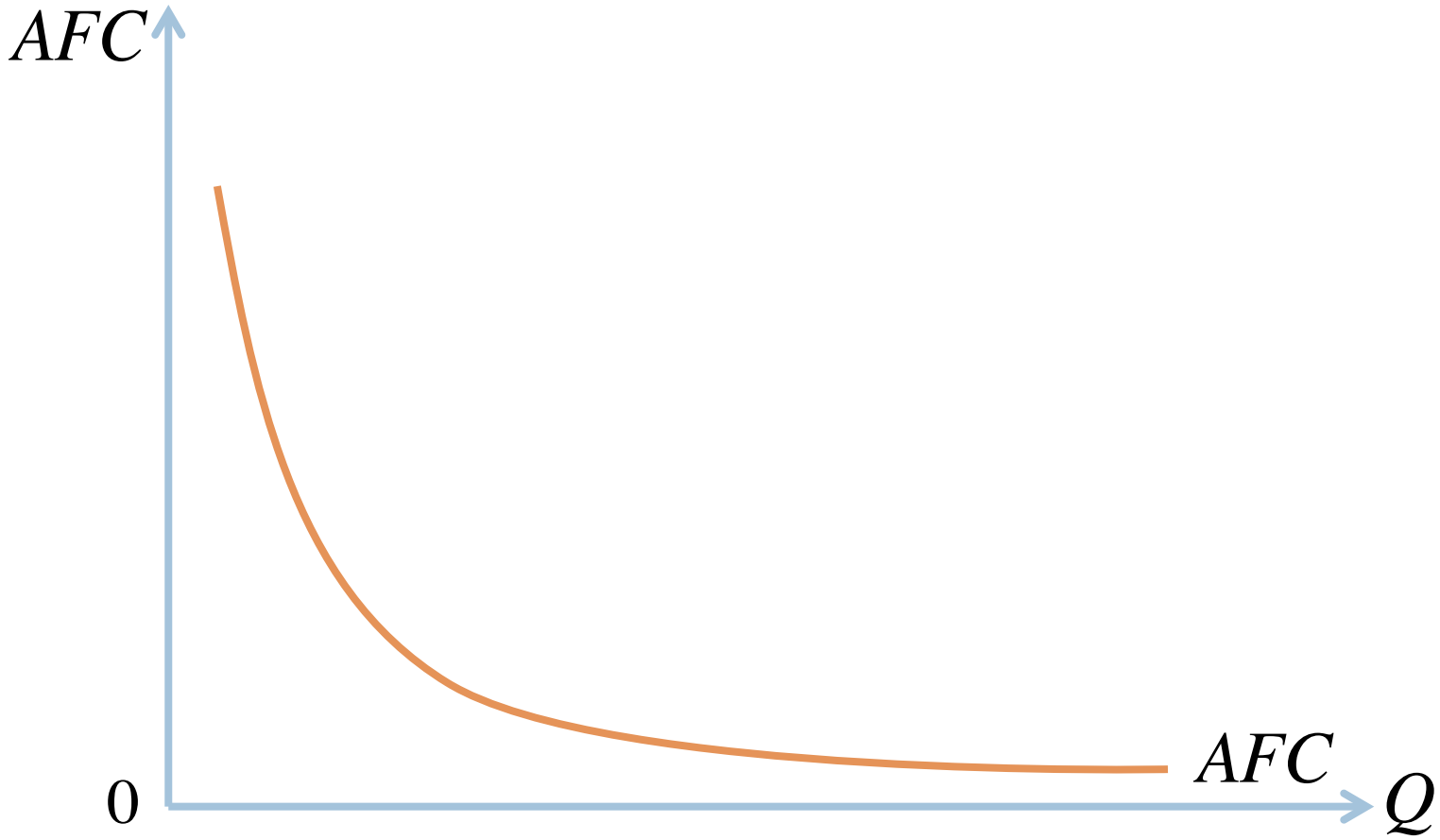
- Definition 8.8 *Average fixed cost (AFC)*

$$AFC(Q) = \frac{FC}{Q}$$

FC is a number, doesn't change with Q.
So similar to 1/x graph.

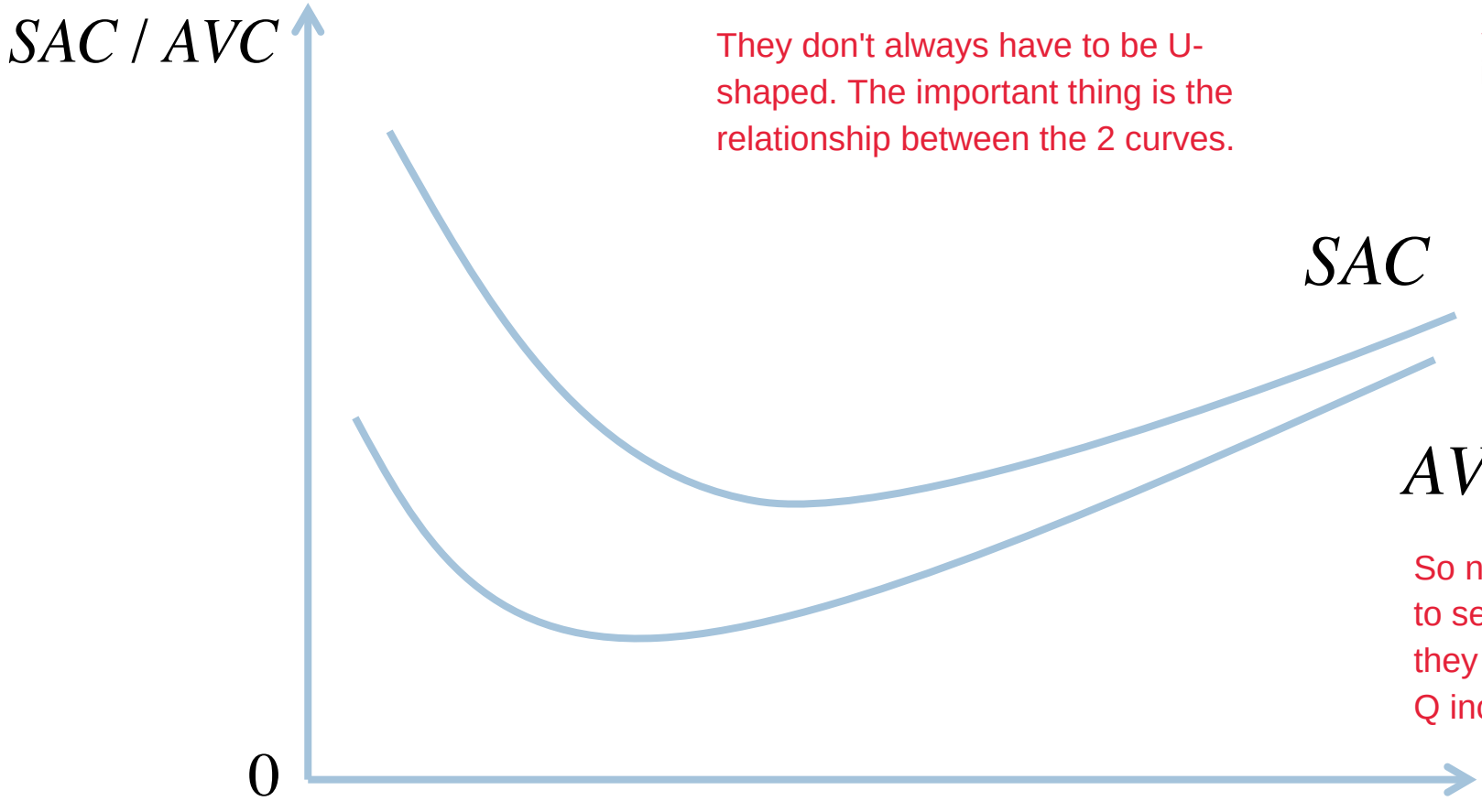
Average Fixed Cost Curve

Exactly how it looks like will depend on how much FC is, but we know its general shape.
one thing for sure: AFC will decrease as Q increases.



if u have typical production process, we will have the typical short-run total cost curve (slide 42), then u will have U-shaped average cost curve as well. So SAC and AVC are U-shaped.

Typical Short-Run Average Cost Curves



They don't always have to be U-shaped. The important thing is the relationship between the 2 curves.

SAC is higher than AVC coz SAC includes both AVC and AFC.

As Q increases, SAC and AVC are getting closer to each other. Coz the different between SAC and AVC is just AFC and we know AFC is decreasing with Q.

So no matter how they look like, we expect to see that SAC is higher than AVC and they get closer and closer to each other as Q increases.

Relationship between *AC* and *MC*

similar to average product and marginal product

General relationship between general value and marginal value.

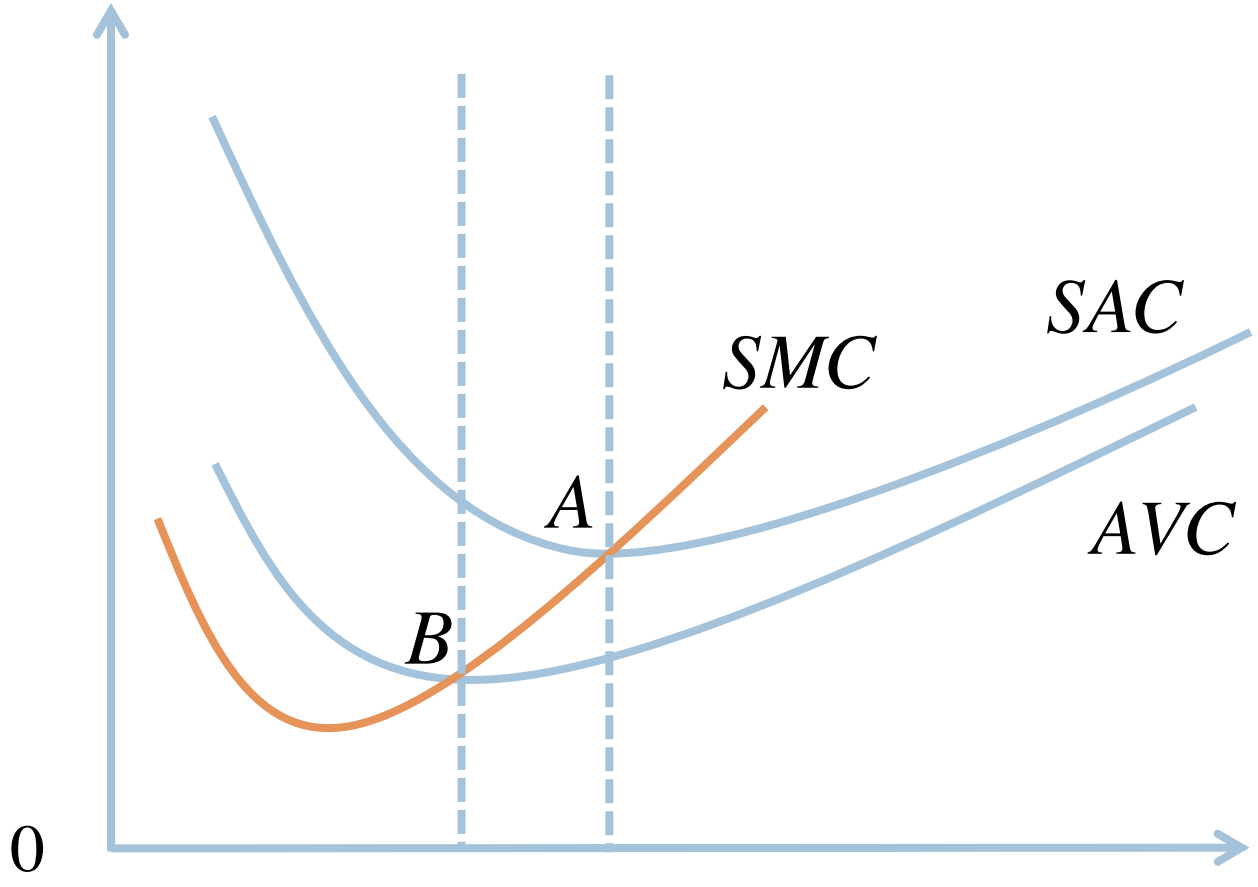
- When *AC* is falling
  - As output increases, average cost goes down
  - The cost of an extra unit of output is pulling down the average
  - *MC<AC*

For AC to decrease, MC has to be lower than AC.

- When *AC* is rising
  - As output increases, average cost goes up
  - The cost of an extra unit of output is pulling up the average
  - *MC>AC*

When AC neither increasing nor decreasing, e.g. at the lowest point of average cost curve, that is where MC = AC.

SMC crosses *SAC* and *AVC* at the minimum points of *SAC* and *AVC*



SMC crosses SAC at the lowest point A.
When SAC is decreasing, SMC lies below SAC, marginal cost is lower than average total cost.
When SAC is increasing, SMC is higher than SAC.

The same relationship holds for SMC and AVC as well.

Question: Can you show the relationship between AVC and SMC mathematically?

Can look at last week, how we showed the relationship between MP and AP.