Explicit vs Implicit costs

Production and Costs

Costs of production

- Economists consider all opportunity costs of production.
- Explicit costs are defined as costs that involve spending money.
- Implicit costs eon the other hand, are nonmonetary opportunity costs.

Costs of production

- Imagine that you want to open a bakery. What are your explicit and implicit costs?

Explicit Costs

- Rental for building (including equipment)
- Cost of utility
- Cost of ingredients (flour, sugar, etc.)
- Cost of worker (you employ a buddy of yours).

Implicit Costs

- The interest you would have earned on the money that you withdrew from your savings account to pay first month's rent and safety deposit.
- Cost of your time: you gave up a job where you were paid hourly.

Costs of production

- Imagine that you want to open a bakery. What are your explicit and implicit costs?

Explicit Costs

- Rental for building $1,600
- Cost of utility $350
- Cost of ingredients $500
- Cost of worker $1,200

Implicit Costs

- The interest you gave up: $50
- Your wage you gave up: $2,100

Alternative scenario

- Imagine that you own the building where you open the bakery. What are your explicit and implicit costs then?

Explicit Costs

- ~~Rental for building $1,600~~
- Cost of utility $350
- Cost of ingredients $500
- Cost of worker $1,200

Implicit Costs

- The foregone rent: $1,600
- The interest you gave up: $50
- Your wage you gave up: $2,100

Economic profit vs Accounting profit

Production and Costs

Profits

- Profits = Total Revenue – Total Costs
- $\pi = P * Q - TC$
- We can approach profit from two points of view: Accountants' and the Economists' point of view.
- Total Revenue is calculated the same way.
- Total Cost is different because Economists include implicit costs as well, Accountants do not.

Profits

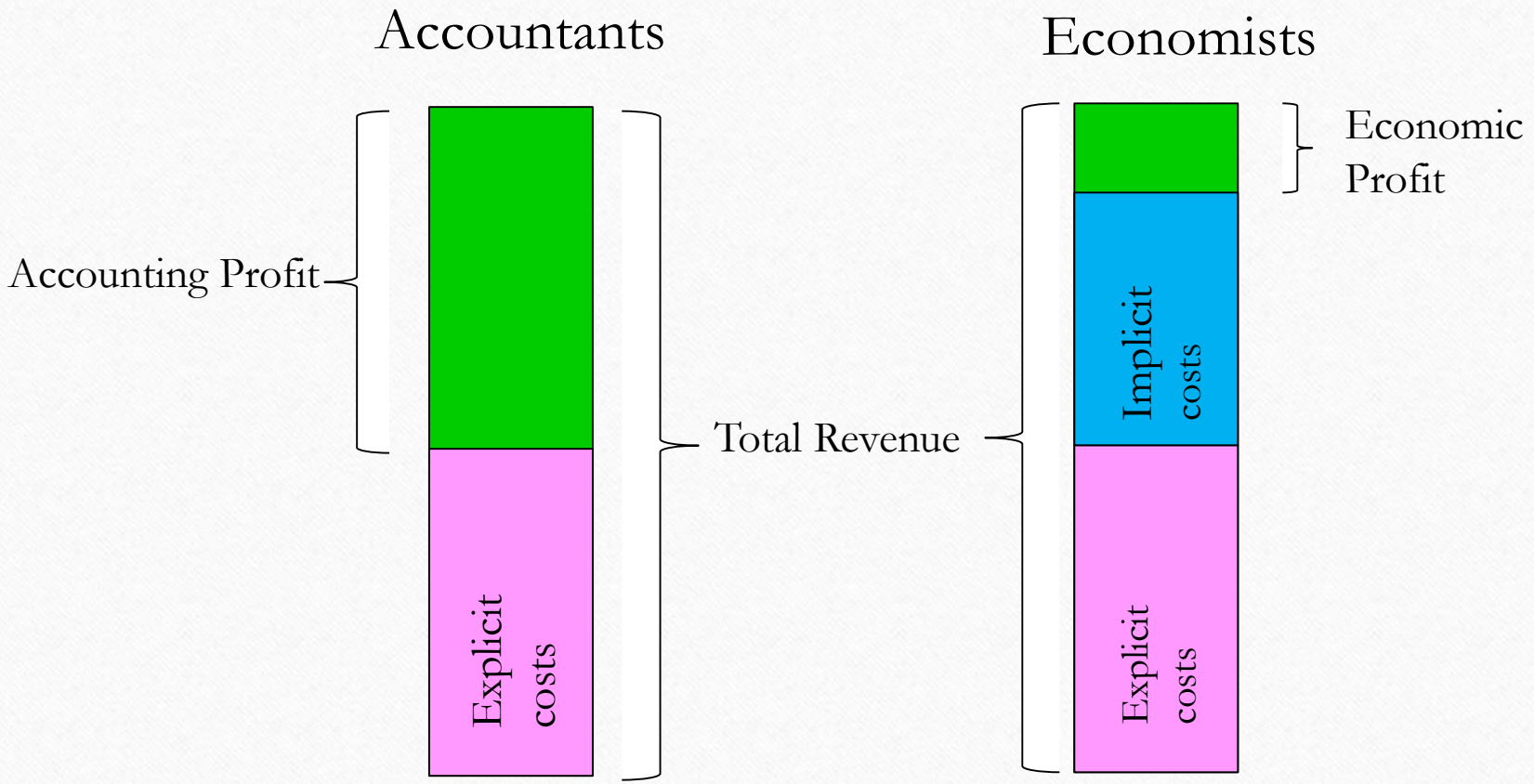
ECONOMISTS

- $\pi = TR - explicit\ costs - implicit\ costs$

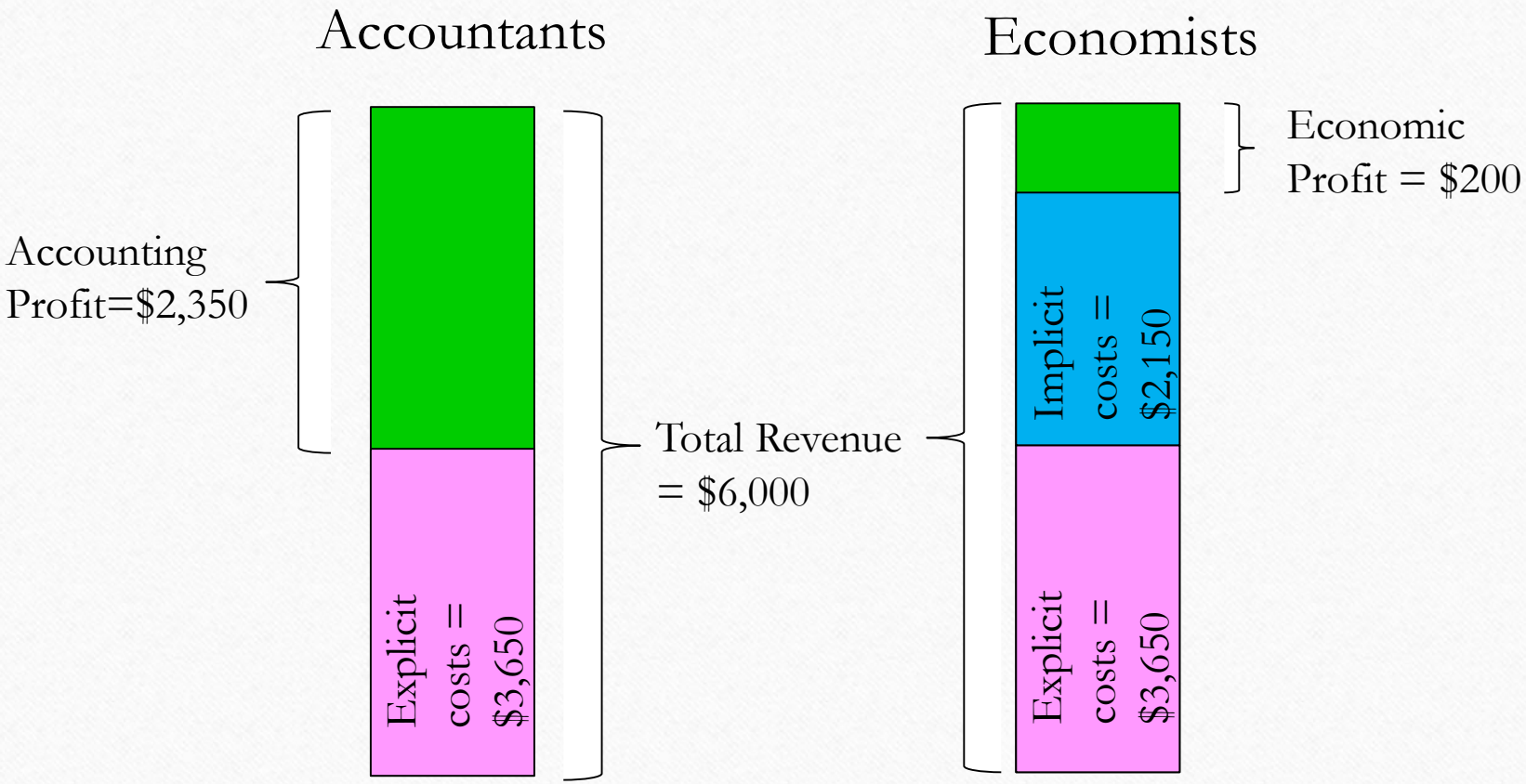
ACCOUNTANTS

- $\pi = TR - explicit\ costs$

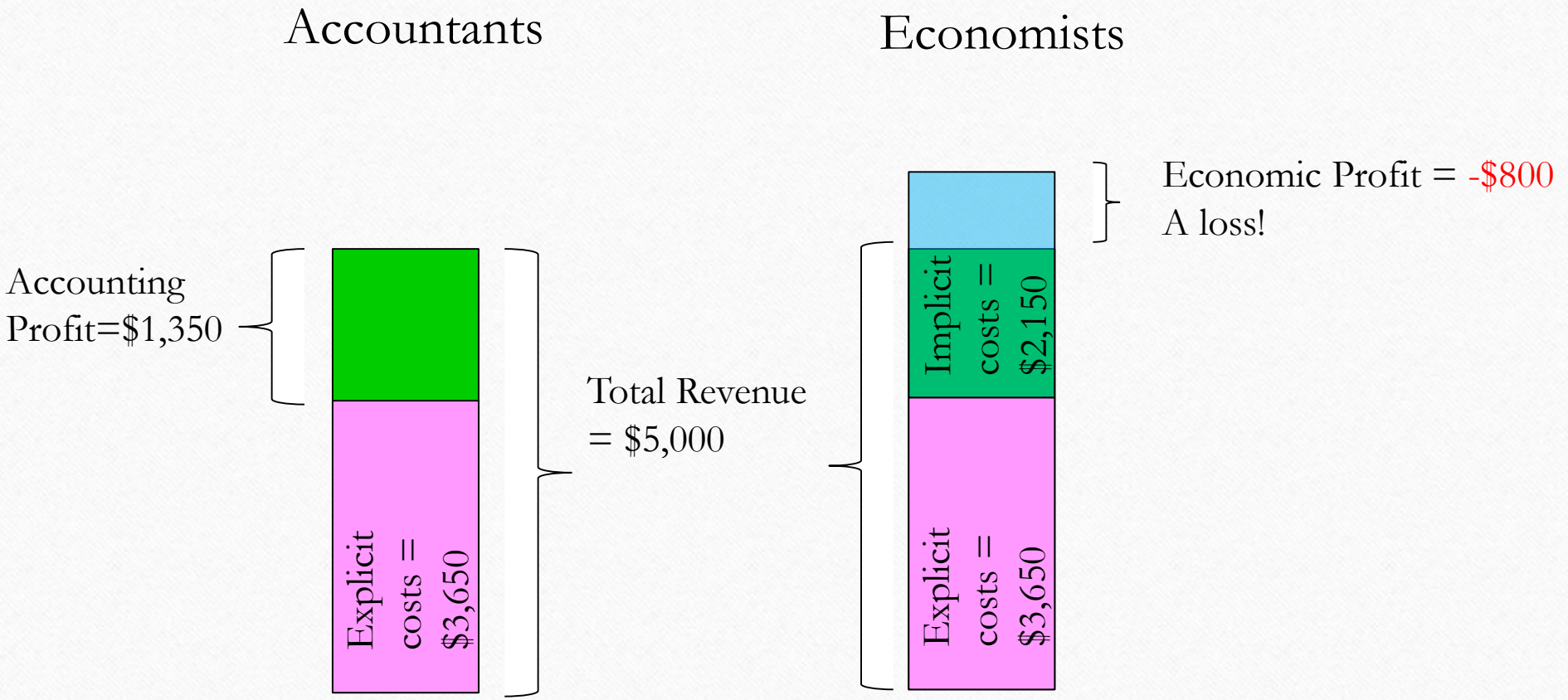
How is profit calculated?



Based on the imaginary bakery…



A different scenario for your bakery…



Lessons

- As long as there are implicit costs, the economic profit will always be smaller than your accounting profit.
- It is possible to have a positive accounting profit, but a negative economic profit at the same time.
  - This means that financially, you could be better off going back to your previous job.
- An economic profit of zero does not mean that you have nothing to eat. It just means that the business is not making you financially better off than what your alternatives are.

Short run vs Long run

Production and Costs

Short Run vs Long Run

- For an economist…
- Short run is the time period during at least one of the inputs is fixed (e.g. the building of the bakery).
- Long run is the time period when all inputs can vary.
- Short vs Long run depends on what business we are talking about.
- The difference between the two is not a constant, like 3 months.

Example: NFL

- Short Run: 2-3 years (however long we are constrained by the size of the current stadium)

It may take several years to increase stadium capacity

Example: hot dog vendor

- Short Run: 1-2 weeks (however long it takes to produce a larger cart or another one)

Let's consider 'our bakery'

- We signed a lease for the building with the equipment for a year.
- We are committed to make monthly payments and it would take time to set up new equipment in the kitchen.
- That year is our short run.

Total, Fixed, Variable costs in the short run

Production and Costs

Short run

- In the short run at least one input is fixed (we cannot change it – we are constrained by the fixed input).
- The other inputs can be changed (increased and decreased) as required.

Short run

- The utilities, the ingredients, and the number or workers we hire are the variable input of our production.
  - These are variable because we can change them (increase or decrease) immediately, which means with the production. If we need to ramp up production, we can hire more workers, buy more flour, etc. If, on the other hand, we need to scale back, we can fire workers, use less of the ingredients and utilities, etc.
- As we established in Module 08c, the building with the kitchen is our fixed input.
  - This cannot be increased or decreased at whim.

Short run costs

- This means that we can group short run costs in the following way:
- Variable Costs (VC): Costs of inputs that change as output changes
- Fixed Costs (FC): Costs of fixed inputs – that remain constant as output changes.

- These two make up the Total Costs (TC): the costs of all inputs.

$$TC = VC + FC$$

Short run costs

- This means that we can group short run costs in the following way:
- Variable Costs (VC): Costs of inputs that change as output changes
- Fixed Costs (FC): Costs of fixed inputs – that remain constant as output changes.

- These two make up the Total Costs (TC): the costs of all inputs.

$$TC = VC + FC$$

To make it simple…

- We usually assume that there is just one fixed input and one variable input, which is usually labor.
- So, to simplify life we can assume that the kitchen is fixed, while the number of workers is variable.

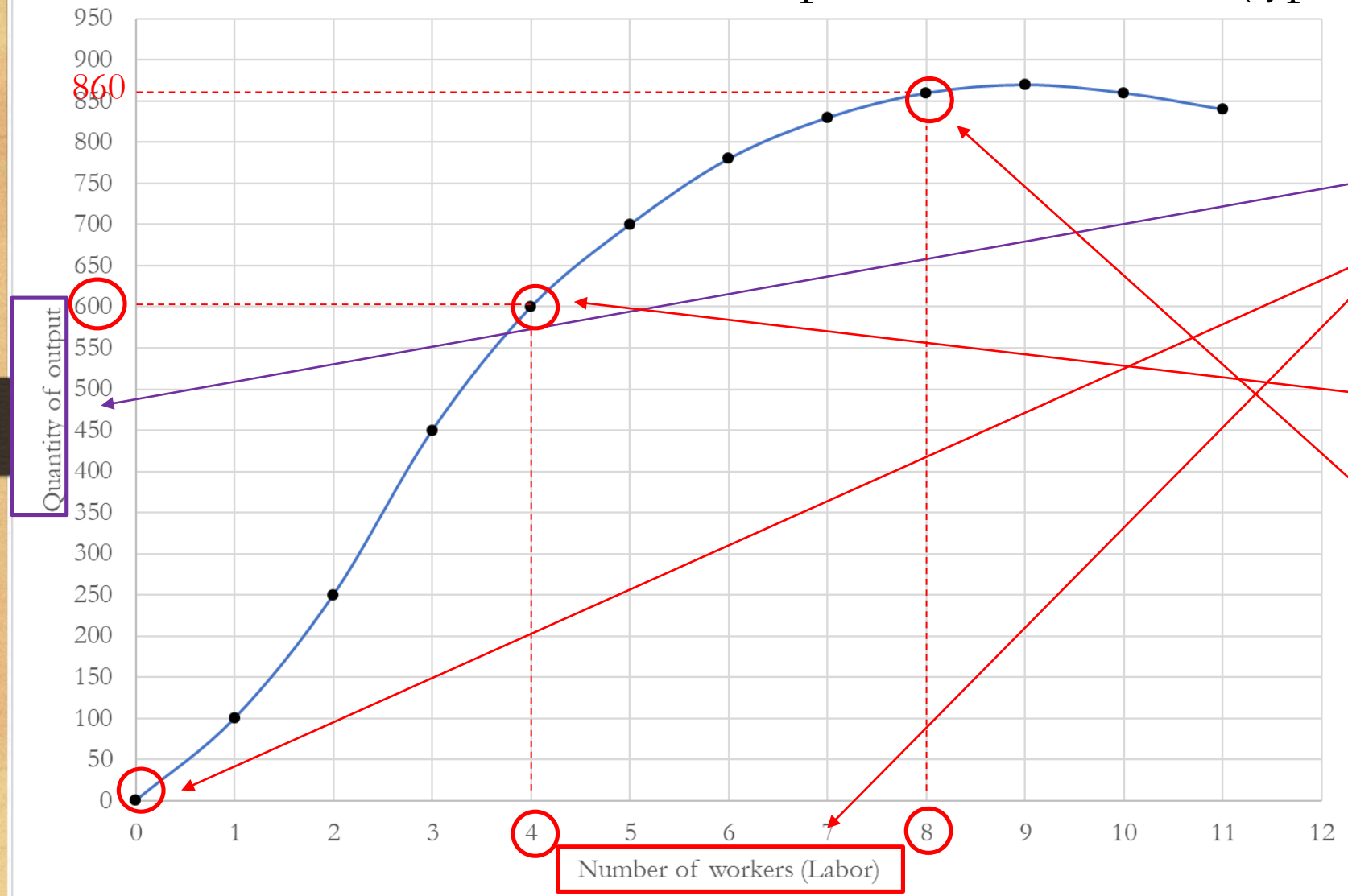
Production functions in the short run

Production and Costs

Production function in the short run

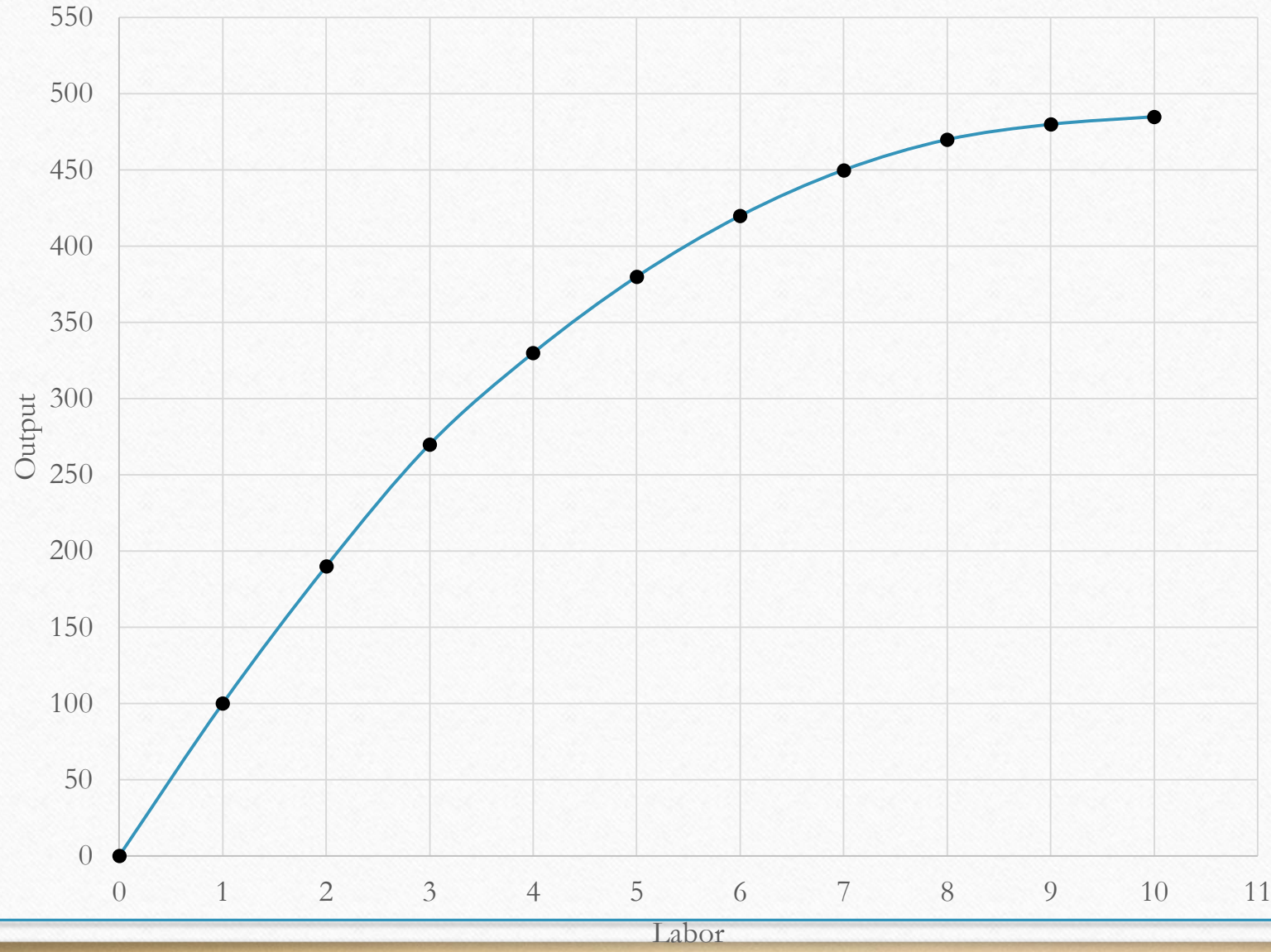
- Production function is a graph showing the relationship between the variable input (usually labor) and the quantity of output produced.
- We simplify the complex world by assuming that there is only 1 variable input (labor).

Short run production function (type I.)



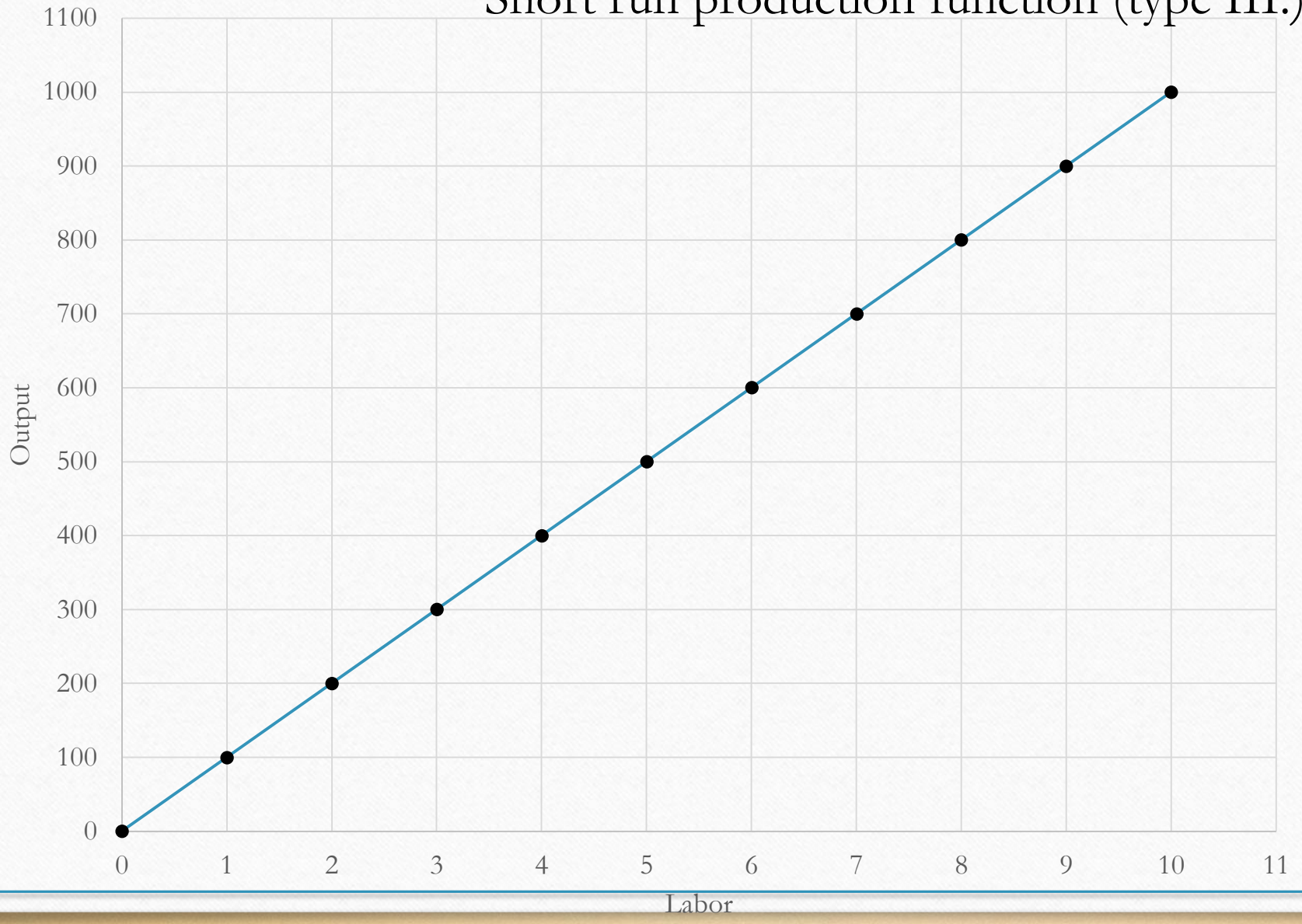
Variable input (Labor)	Quantity produced
0	0
1	100
2	250
3	450
4	600
5	700
6	780
7	830
8	860
9	870
10	860
11	840

Short run production function (type II.)



Labor	Output
0	0
1	100
2	190
3	270
4	330
5	380
6	420
7	450
8	470
9	480
10	485

Short run production function (type III.)

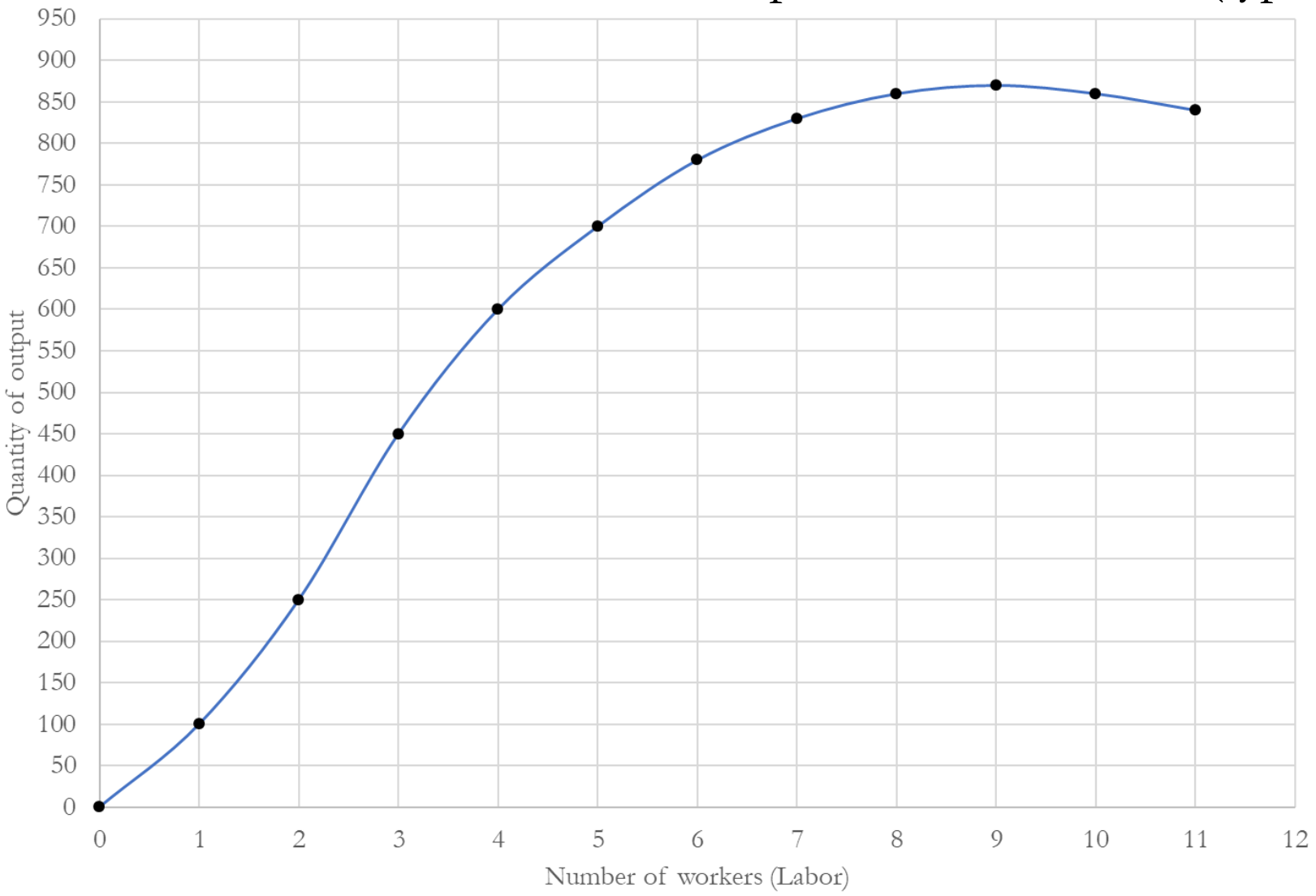


Labor	Output
0	0
1	100
2	200
3	300
4	400
5	500
6	600
7	700
8	800
9	900
10	1000

Average Product vs Marginal Product

Production and Costs

Short run production function (type I.)



Variable input (Labor)	Quantity produced
0	0
1	100
2	250
3	450
4	600
5	700
6	780
7	830
8	860
9	870
10	860
11	840

Average Products

- Average Product of a variable input is the total quantity produced divided by the number of the variable inputs used to produce that quantity.
- Usually we are interested in the Average product of labor (AP_L)

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

- Basically, the average product of labor is the output produced by your 'typical' worker.
- Obviously, this may change depending on how many workers you have.

Labor	Output (Q)	Average Product of Labor ($AP_L=Q/L$)
0	0	-
1	100	100.00
2	250	125.00
3	450	150.00
4	600	150.00
5	700	140.00
6	780	130.00
7	830	118.57
8	860	107.50
9	870	96.67
10	860	86.00
11	840	76.36

How do we get the 150 for the average product of labor?

$$150 = \frac{450}{3}$$

How do we get the 96.67 for the average product of labor?

$$96.67 = \frac{870}{9}$$

Marginal Product

- The marginal product of any input in the production process is the increase in the quantity of output obtained from an additional unit of that input.

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

- Diminishing marginal product is the property whereby the marginal product of an input declines as the quantity of the input increases.

Labor	Output (Q)	Average Product of Labor ($AP_L=Q/L$)	Marginal Product of Labor ($MP_L=\Delta Q/\Delta L$)
0	0	-	-
1	100	100.00	100
2	250	125.00	150
3	450	150.00	200
4	600	150.00	150
5	700	140.00	100
6	780	130.00	80
7	830	118.57	50
8	860	107.50	30
9	870	96.67	10
10	860	86.00	-10
11	840	76.36	-20

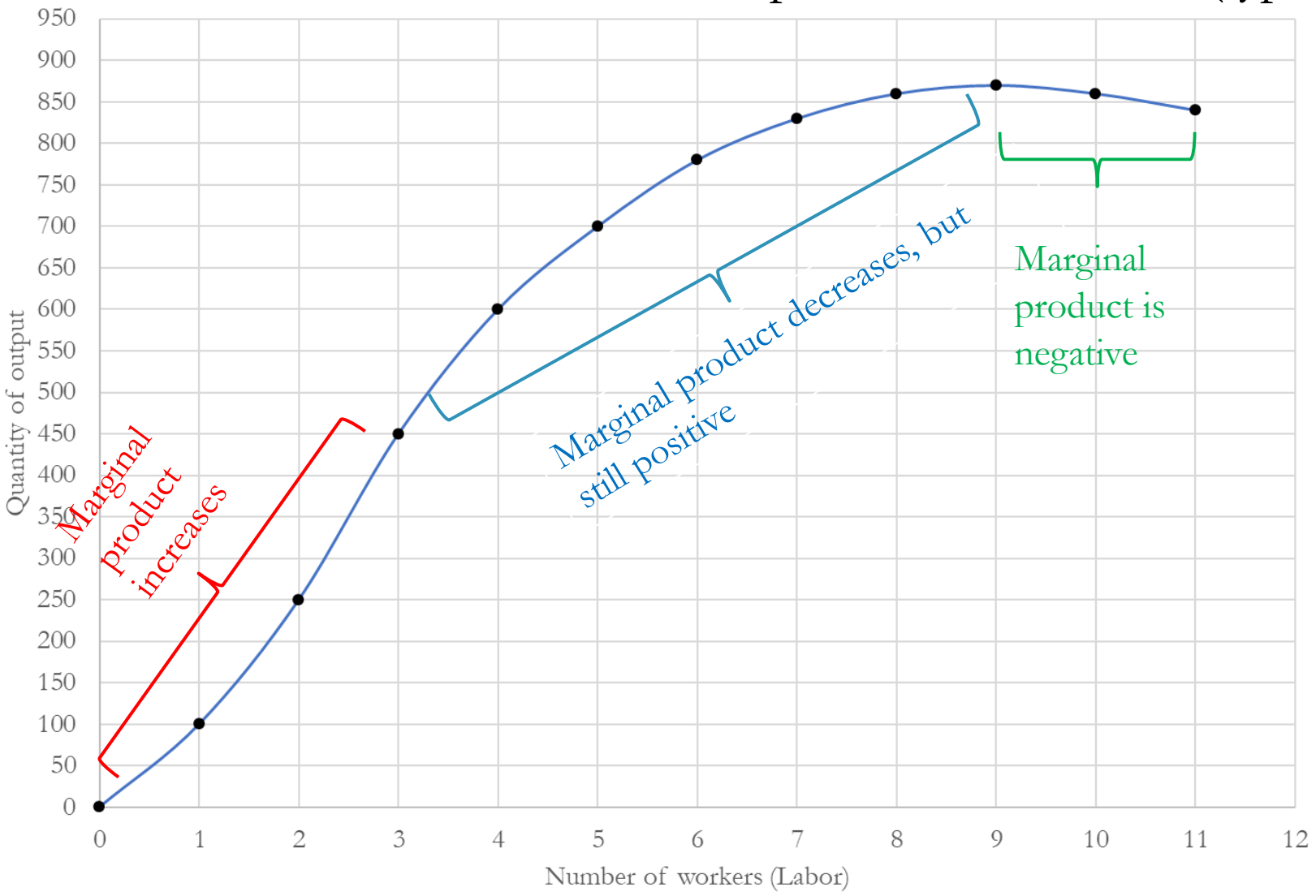
How do we get the 200, which is the marginal product of the third worker?

$$200 = \frac{450 - 250}{3 - 2}$$

How do we get the 10 for the marginal product of labor?

$$10 = \frac{870 - 860}{9 - 8}$$

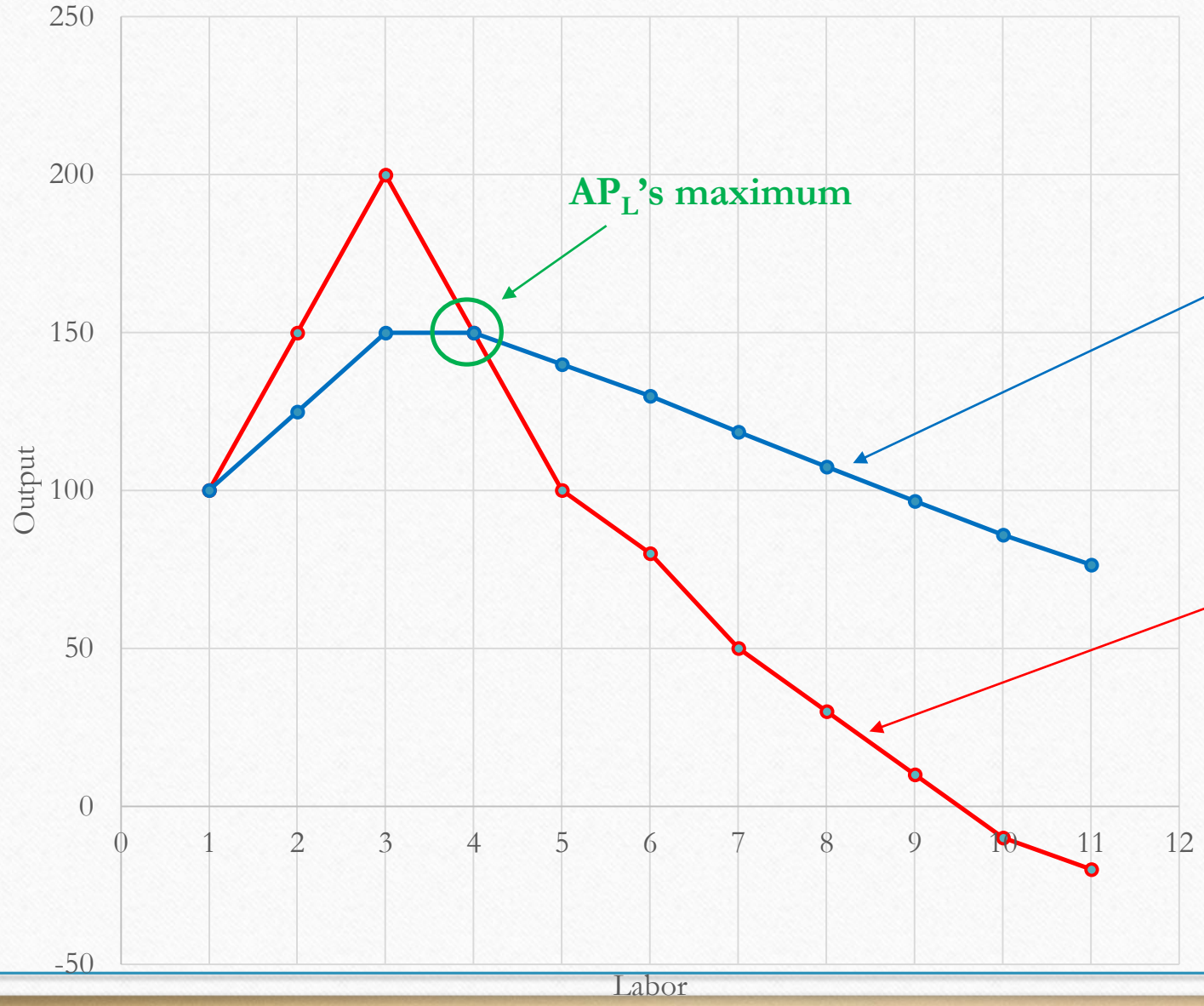
Short run production function (type I.)



Variable input (Labor)	Quantity produced
0	0
1	100
2	250
3	450
4	600
5	700
6	780
7	830
8	860
9	870
10	860
11	840

If we were to graph the AP_L and MP_L on the same graph, with Q on the horizontal axis and quantity on the vertical axis, what would that graph look like?

Labor	Output (Q)	Average Product of Labor ($AP_L=Q/L$)	Marginal Product of Labor ($MP_L=\Delta Q/\Delta L$)
0	0	-	-
1	100	100.00	100
2	250	125.00	150
3	450	150.00	200
4	600	150.00	150
5	700	140.00	100
6	780	130.00	80
7	830	118.57	50
8	860	107.50	30
9	870	96.67	10
10	860	86.00	-10
11	840	76.36	-20



L	Q	AP_L	MP_L
0	0	-	-
1	100	100.00	100
2	250	125.00	150
3	450	150.00	200
4	600	150.00	150
5	700	140.00	100
6	780	130.00	80
7	830	118.57	50
8	860	107.50	30
9	870	96.67	10
10	860	86.00	-10
11	840	76.36	-20

Relationship between marginal and average

Classes	Grades
Math	3
English	4
Physics	2
PolSci	4
History	2
GPA	**3**

Your next class is economics.

↓

Econ grade: 4

Classes	Grades
Math	3
English	4
Physics	2
PolSci	4
History	2
ECONOMICS	**4**
GPA	**3.166667**

Your average has increased!

When your marginal is ABOVE your average, your average will increase!

Relationship between marginal and average

Classes	Grades
Math	3
English	4
Physics	2
PolSci	4
History	2
GPA	**3**

Your next class is art.

Art grade: 2

Classes	Grades
Math	3
English	4
Physics	2
PolSci	4
History	2
ART	**2**
GPA	**2.833333**

Your average has decreased!

When your marginal is BELOW your average, your average will decrease!

Relationship between marginal and average product

- Where marginal product goes through average product, average product reaches its maximum (highest point)

Practice – Average Product vs Marginal Product

Production and Costs

Exercise 1

- In Module 08f we looked at how Average product and marginal product is calculated and we presented the graph of AP_L and MP_L for the type I short run production function.
- In Exercise 1, you will do the same for the type II production function presented in Module 08e.

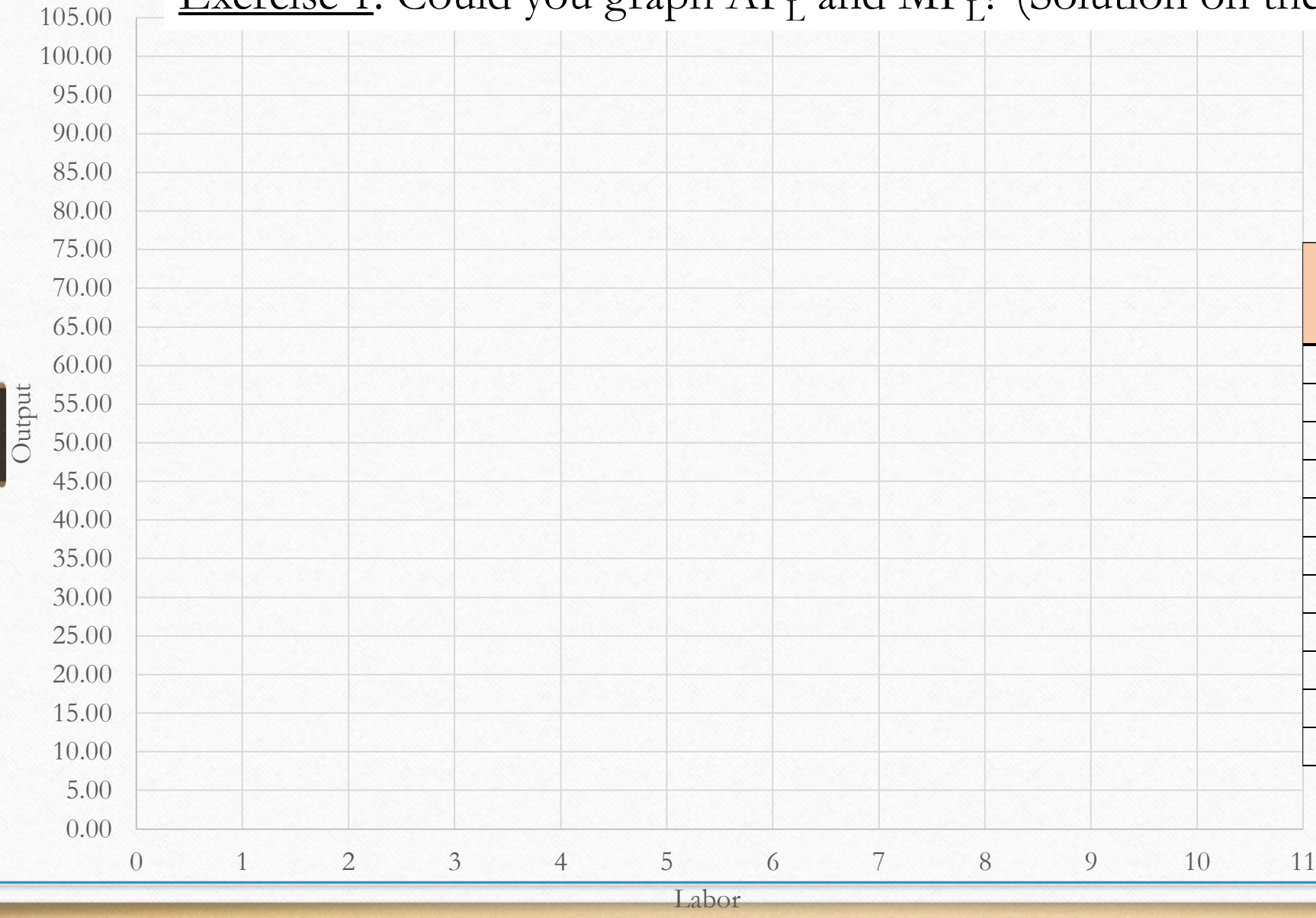
Exercise 1: Calculate the missing AP_L and MP_L (solution is provided on the next slide)

L	Q	AP_L	MP_L
0	0	-	-
1	100		
2	190		
3	270		
4	330		
5	380		
6	420		
7	450		
8	470		
9	480		
10	485		

Exercise 1: Calculation Solution

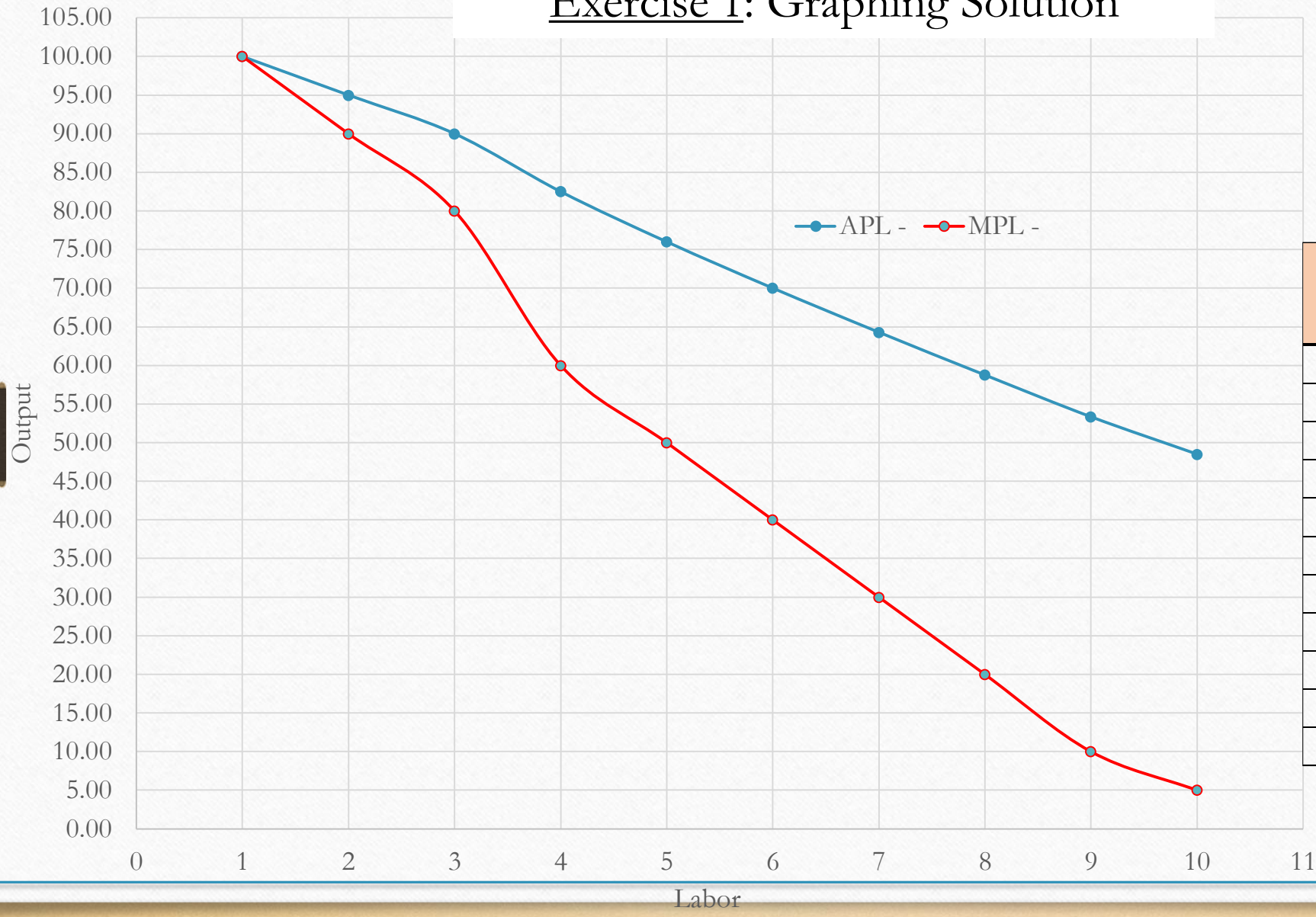
L	Q	AP_L	MP_L
0	0	-	-
1	100	100.00	100
2	190	95.00	90
3	270	90.00	80
4	330	82.50	60
5	380	76.00	50
6	420	70.00	40
7	450	64.29	30
8	470	58.75	20
9	480	53.33	10
10	485	48.50	5

Exercise 1: Could you graph AP_L and MP_L? (Solution on the next slide)



L	Q	AP_L	MP_L
0	0	-	-
1	100	100.00	100
2	190	95.00	90
3	270	90.00	80
4	330	82.50	60
5	380	76.00	50
6	420	70.00	40
7	450	64.29	30
8	470	58.75	20
9	480	53.33	10
10	485	48.50	5

Exercise 1: Graphing Solution



L	Q	AP_L	MP_L
0	0	-	-
1	100	100.00	100
2	190	95.00	90
3	270	90.00	80
4	330	82.50	60
5	380	76.00	50
6	420	70.00	40
7	450	64.29	30
8	470	58.75	20
9	480	53.33	10
10	485	48.50	5

Exercise 2

- Let's repeat these steps for the type III production function presented in Module 08e.
- So, you will calculate and graph AP_L and MP_L

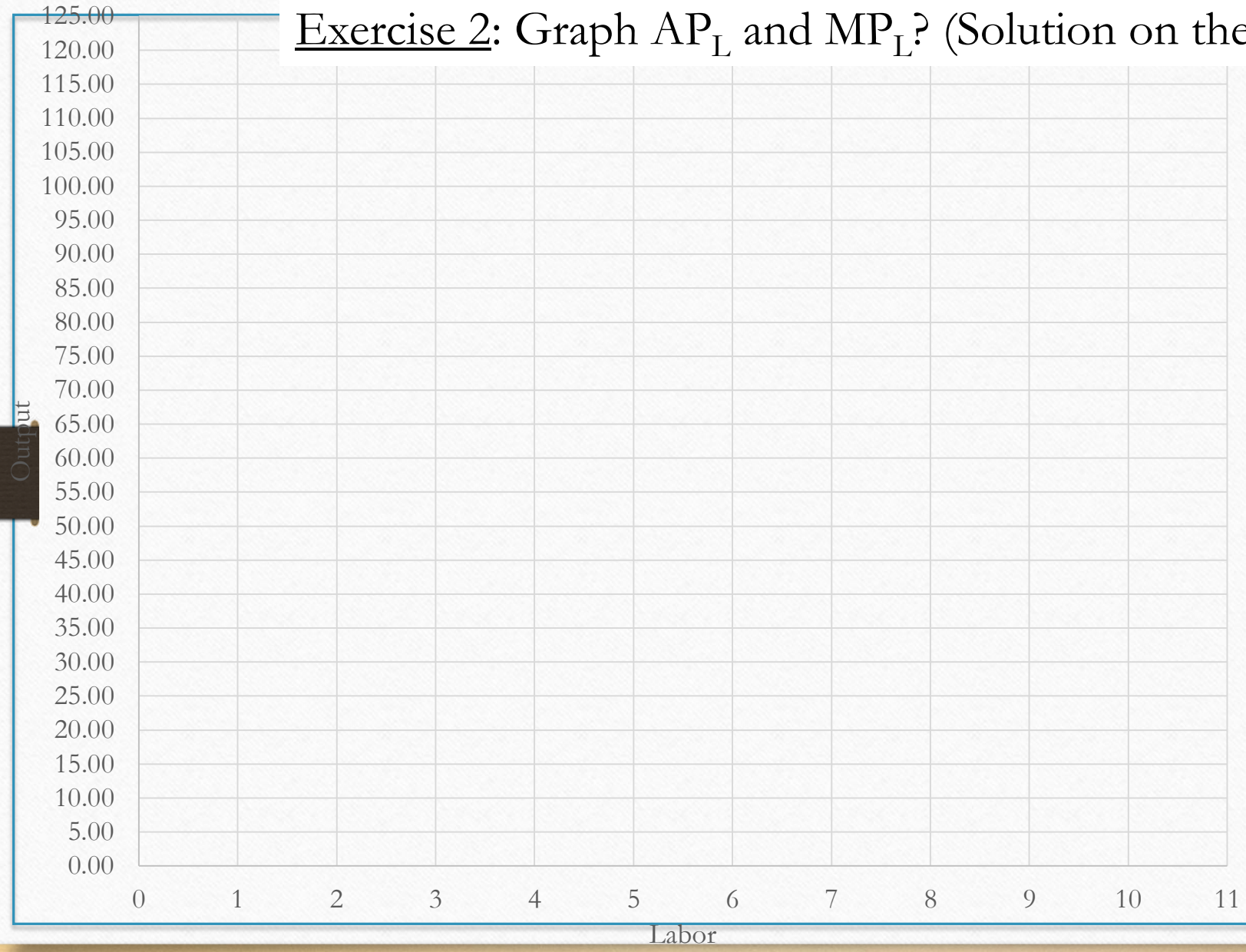
Exercise 2: Calculate the missing AP_L and MP_L (solution is provided on the next slide)

L	Q	AP_L	MP_L
0	0	-	-
1	100		
2	200		
3	300		
4	400		
5	500		
6	600		
7	700		
8	800		
9	900		
10	1000		

Exercise 2: Calculation Solution

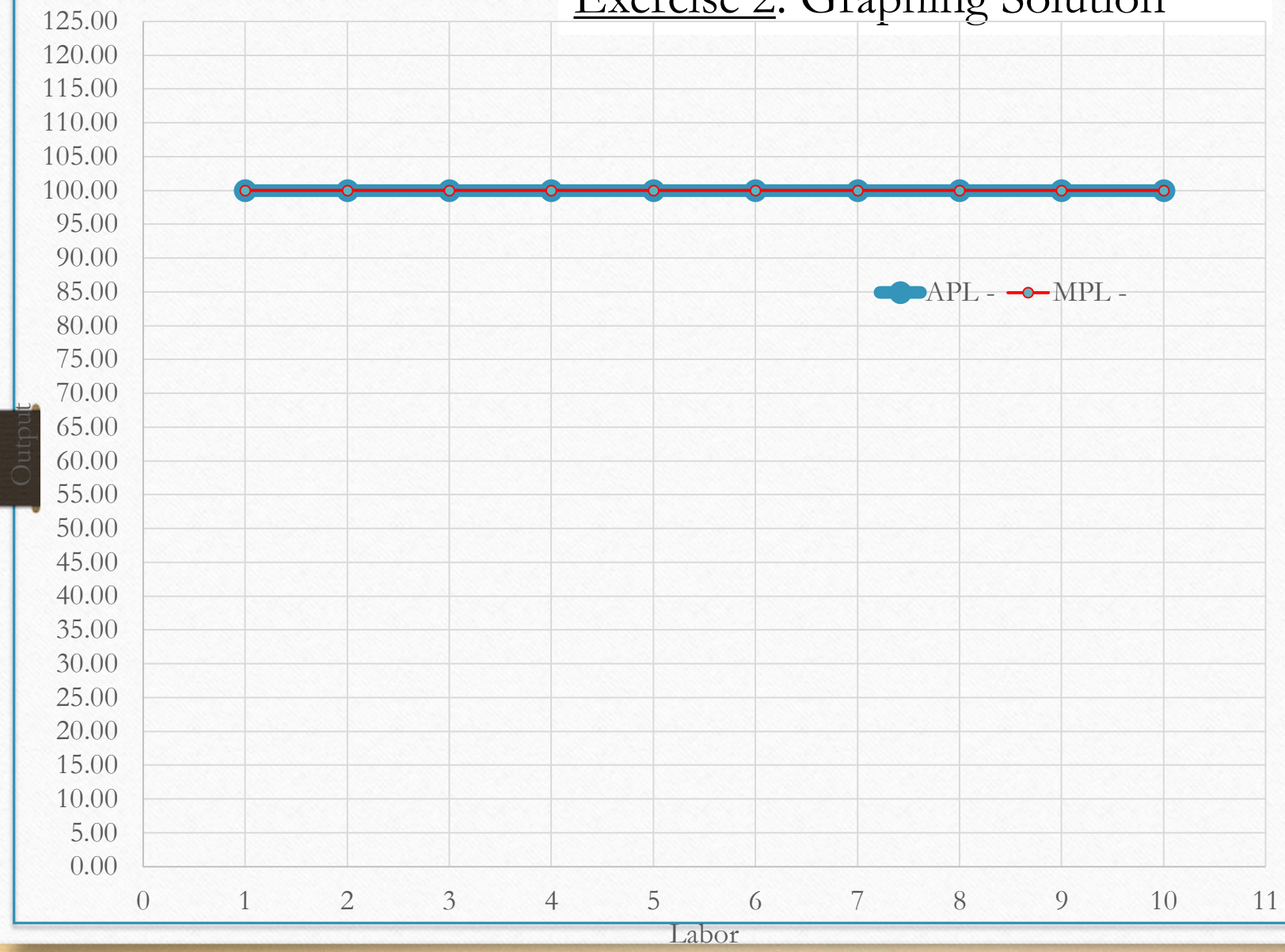
L	Q	AP_L	MP_L
0	0	-	-
1	100	100.00	100
2	200	100.00	100
3	300	100.00	100
4	400	100.00	100
5	500	100.00	100
6	600	100.00	100
7	700	100.00	100
8	800	100.00	100
9	900	100.00	100
10	1000	100.00	100

Exercise 2: Graph AP_L and MP_L? (Solution on the next slide)



L	Q	AP_L	MP_L
0	0	-	-
1	100	100.00	100
2	200	100.00	100
3	300	100.00	100
4	400	100.00	100
5	500	100.00	100
6	600	100.00	100
7	700	100.00	100
8	800	100.00	100
9	900	100.00	100
10	1000	100.00	100

Exercise 2: Graphing Solution



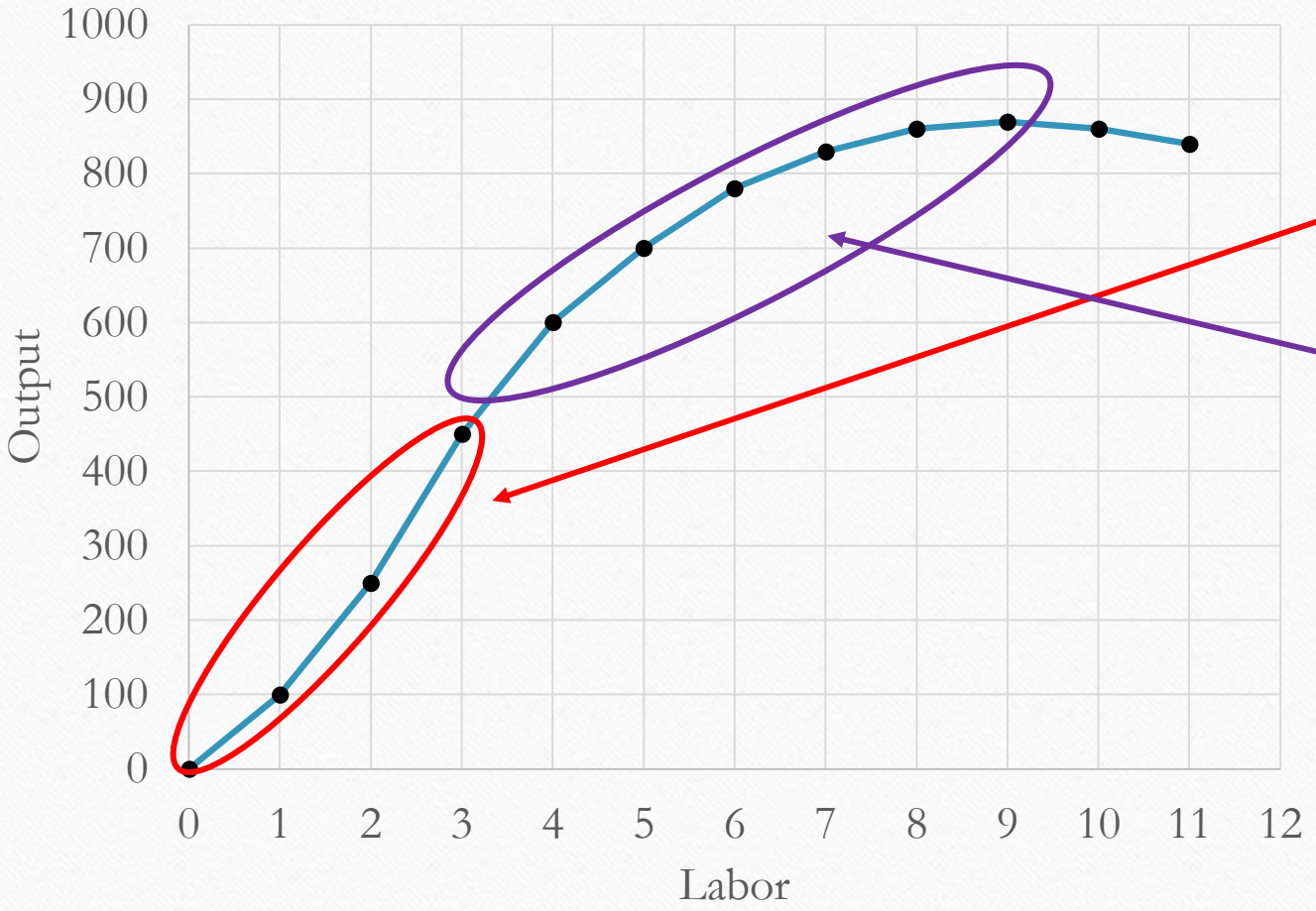
L	Q	AP_L	MP_L
0	0	-	-
1	100	100.00	100
2	200	100.00	100
3	300	100.00	100
4	400	100.00	100
5	500	100.00	100
6	600	100.00	100
7	700	100.00	100
8	800	100.00	100
9	900	100.00	100
10	1000	100.00	100

Characteristics of short-run production functions

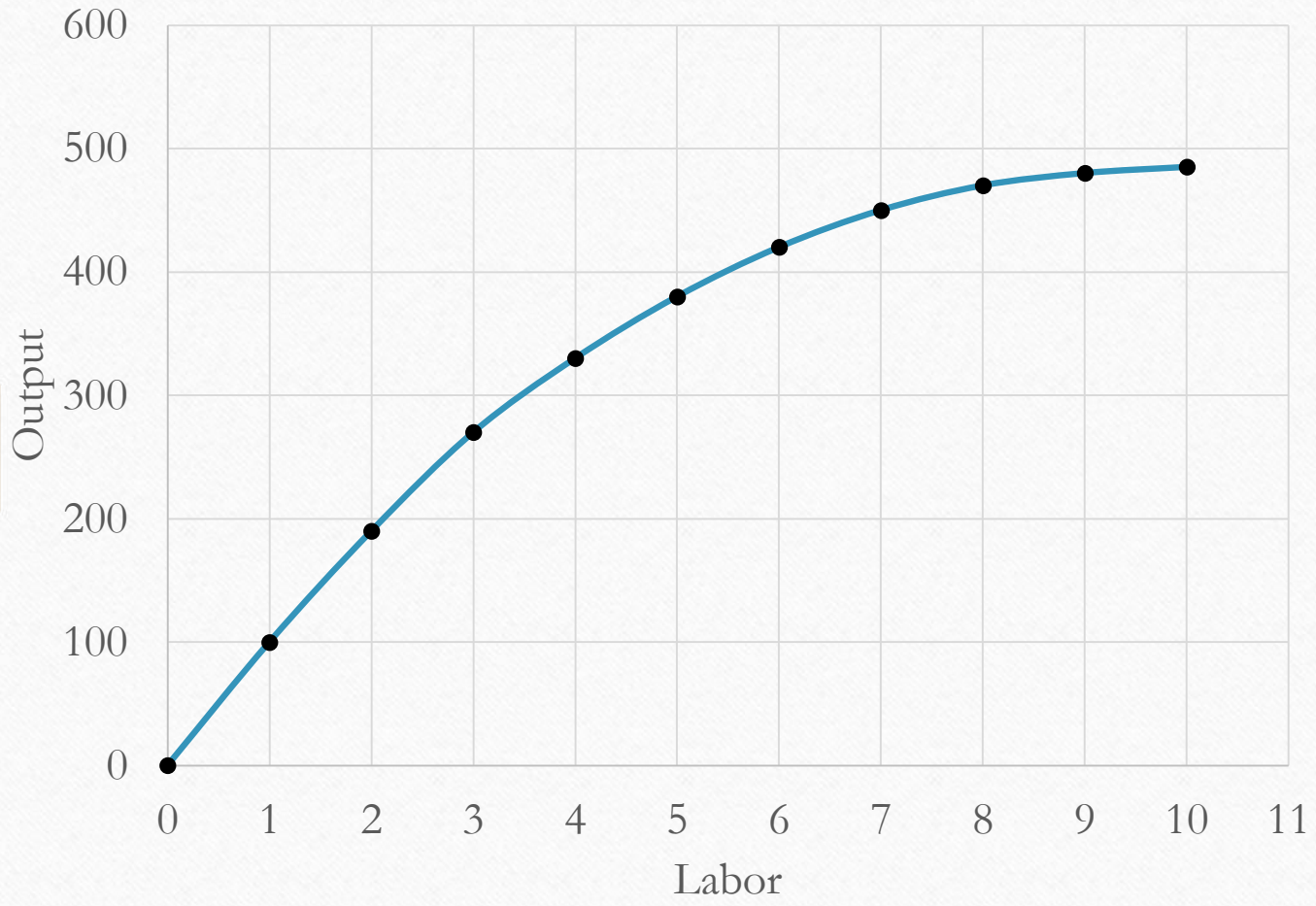
Production and Costs

Review of the characteristics of production functions in the short run

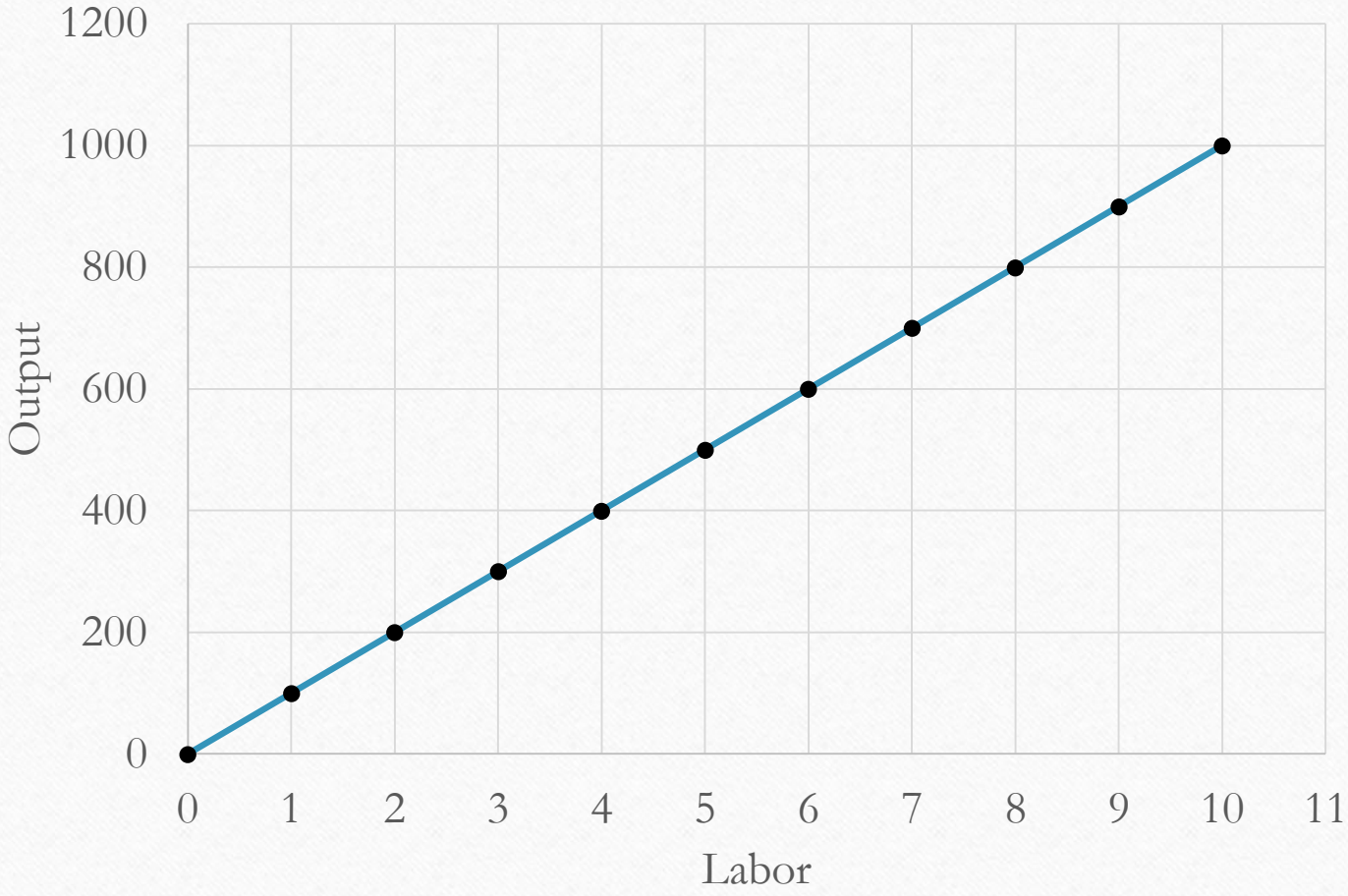
- Let's do a short review based on what we learned in Modules 08f and 08g.



This type of production function exhibits **increasing MPL first**, but after a certain number of workers **diminishing MPL** hits in.



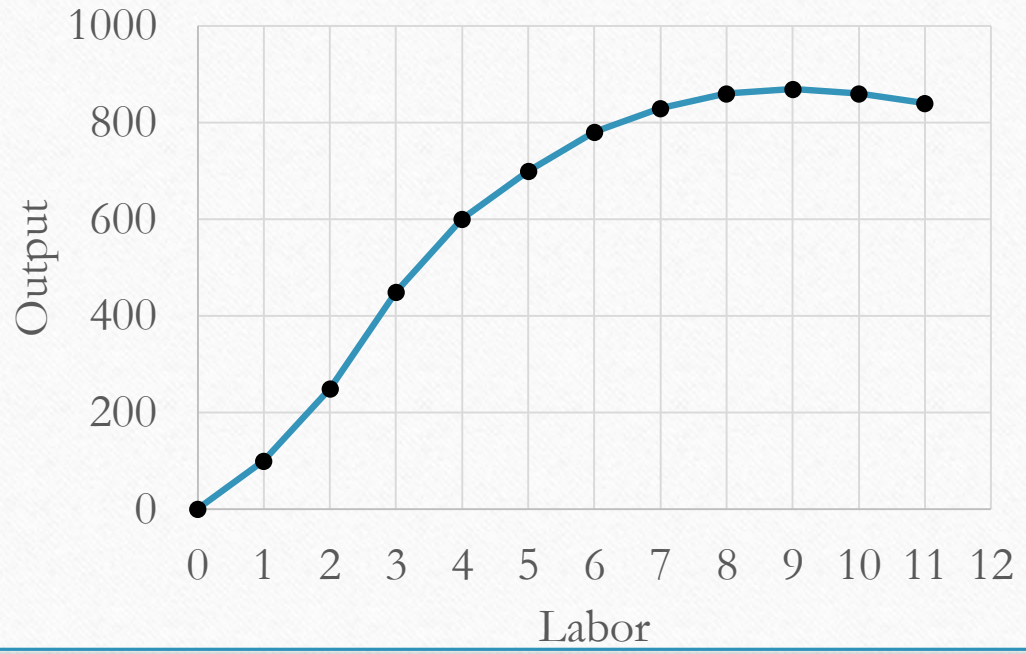
This type of production function where **diminishing MPL** hits in right away.



This type of production function exhibits constant **MPL**. The slope of the production function is the same everywhere.

Which production function do you think is most realistic?

- Out of the three, which is the one that seems most likely to occur in real life?



TC, VC, FC

Production and Costs

Costs of our business

- Let's show how we can get Total Costs from a production table knowing how much workers are paid and what we pay after our fixed input.

Total cost, Variable cost, and Fixed cost of short-run production

L	Q	Fixed Cost (FC)	Variable Cost (VC)	Total Cost (TC)
0	0			
1	100			
2	250			
3	450			
4	600			
5	700			
6	780			
7	830			
8	860			
9	870			
10	860			
11	840			

Let's say that this is the production table for your business' weekly operation.

What are your FC, VC and TC if your weekly costs are the following?

- You pay a weekly rent of $250 (you are obligated to pay this for a year)
- You pay each worker a weekly wage of $200 (they only work a few hours a day and you can hire & fire them as necessary)

Total cost, Variable cost, and Fixed cost of short-run production

L	Q	Fixed Cost (FC)	Variable Cost (VC)	Total Cost (TC)
0	0	$250	$0	
1	100	$250	$200	
2	250	$250	$400	
3	450	$250	$600	
4	600	$250	$800	
5	700	$250	$1,000	
6	780	$250	$1,200	
7	830	$250	$1,400	
8	860	$250	$1,600	
9	870	$250	$1,800	
10	860	$250	$2,000	
11	840	$250	$2,200	

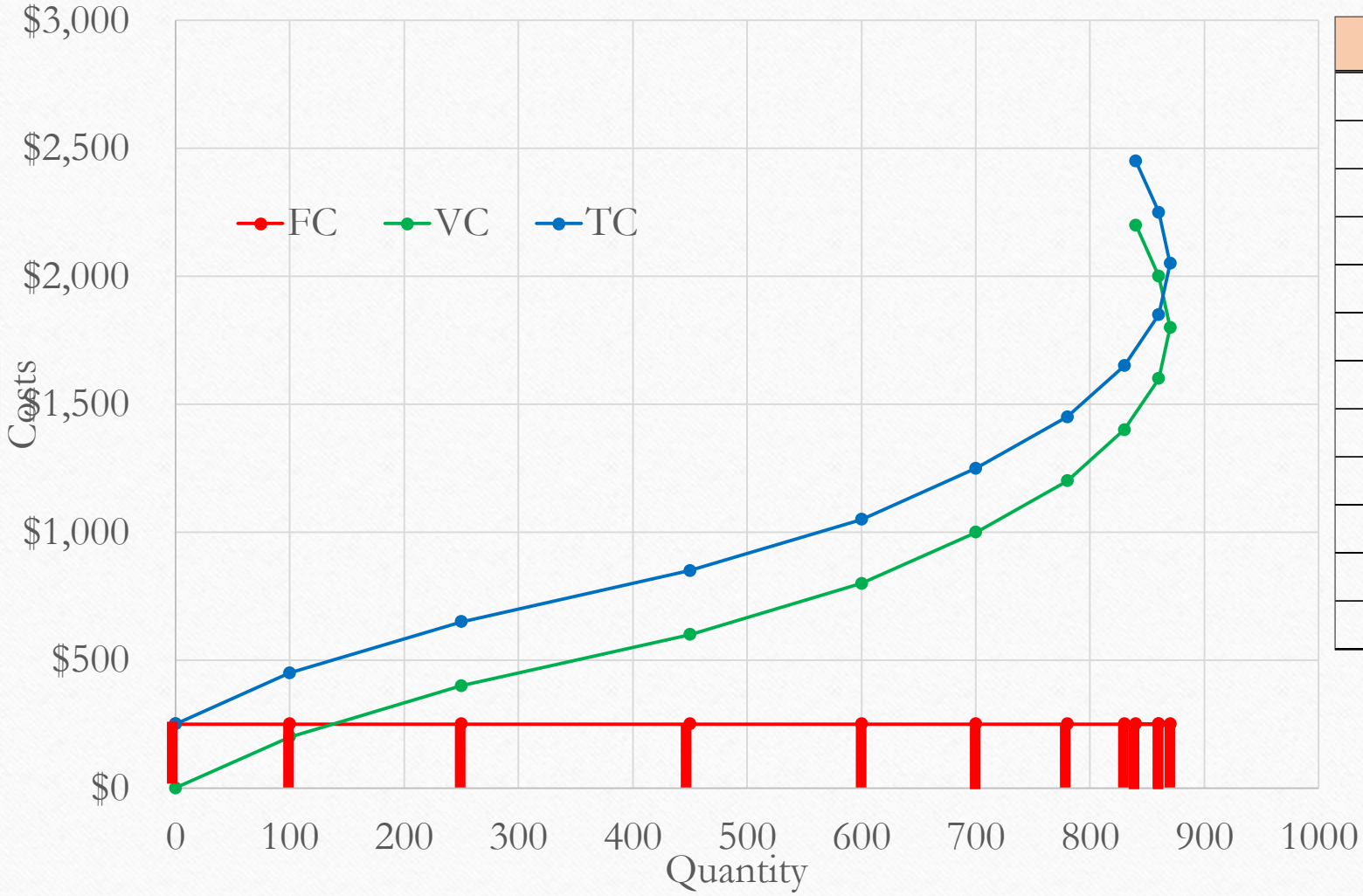
- The weekly rent of $250 is a Fixed Cost.
  - You have to pay this regardless of the output. You pay it even if Q=0, but you do not have to pay more for rent when your Q=870.
- The worker's wage of $200 is a Variable Cost
  - This **varies** with the level of production. When you produce nothing, you will fire your workers and pay $0, however, if you want to crank up production, you need to hire more workers.

Total cost, Variable cost, and Fixed cost of short-run production

L	Q	Fixed Cost (FC)	Variable Cost (VC)	Total Cost (TC)
0	0	$250	$0	$250
1	100	$250	$200	$450
2	250	$250	$400	$650
3	450	$250	$600	$850
4	600	$250	$800	$1,050
5	700	$250	$1,000	$1,250
6	780	$250	$1,200	$1,450
7	830	$250	$1,400	$1,650
8	860	$250	$1,600	$1,850
9	870	$250	$1,800	$2,050
10	860	$250	$2,000	$2,250
11	840	$250	$2,200	$2,450

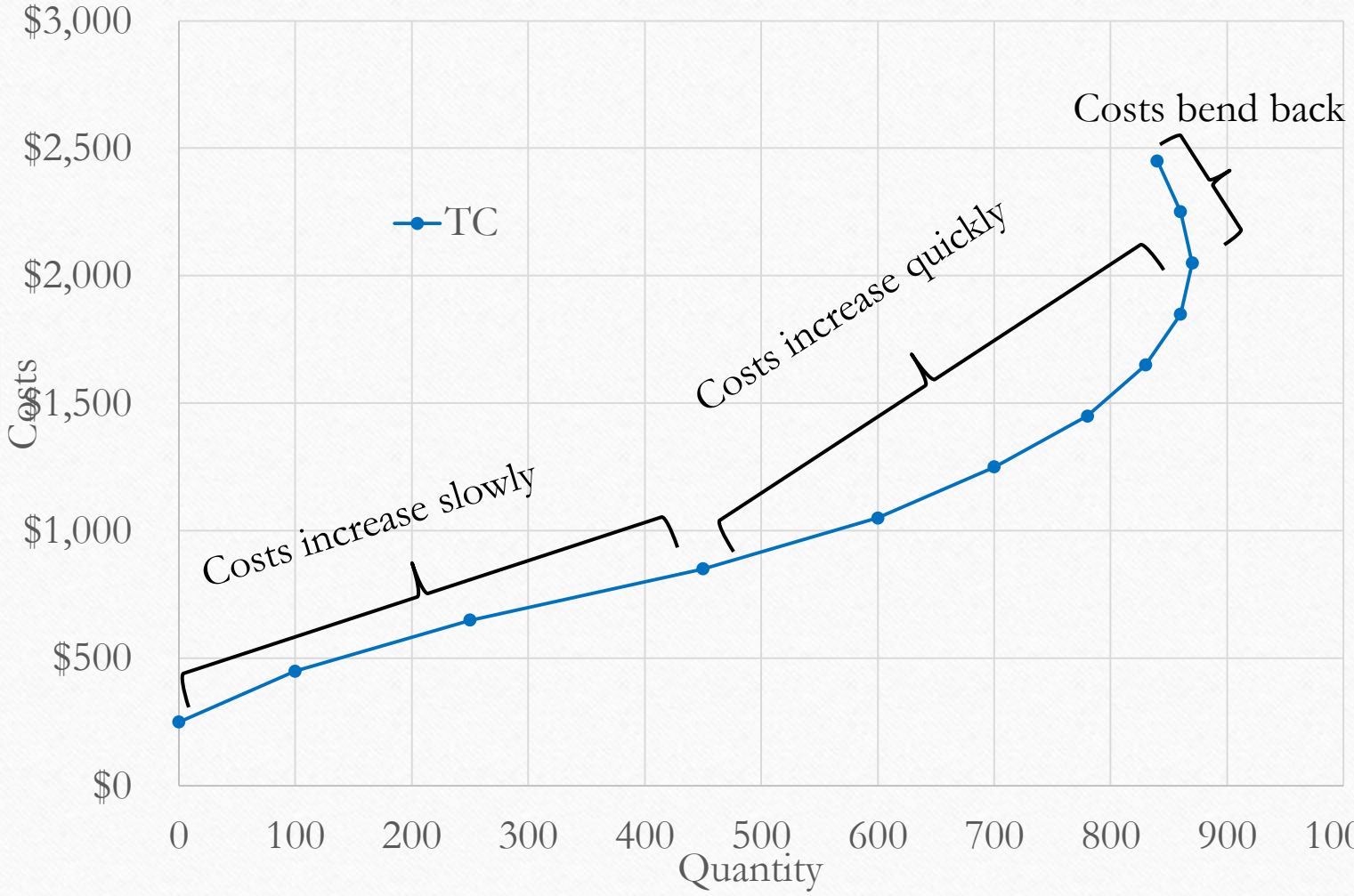
- Total Cost = Fixed Cost + Variable Cost.
- For instance, when production is 600 (which is obtained by having 4 workers) your fixed cost is $250, your variable cost is 4*$200=$800. The sum is $1,050.

Graphing Costs

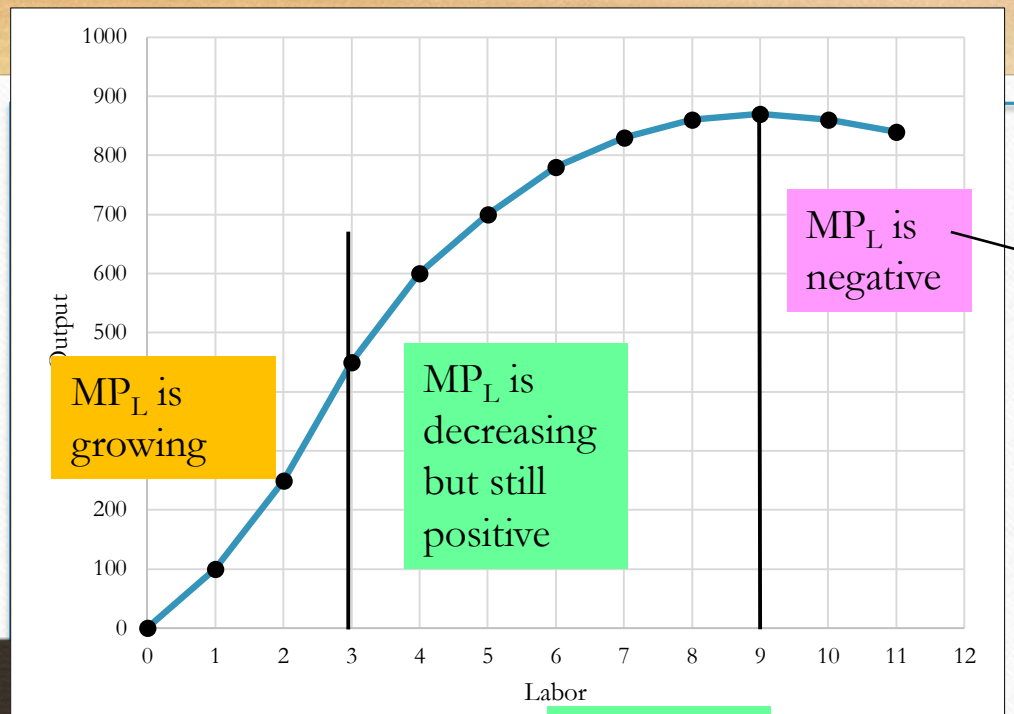


L	Q	FC	VC	TC
0	0	$250	$0	$250
1	100	$250	$200	$450
2	250	$250	$400	$650
3	450	$250	$600	$850
4	600	$250	$800	$1,050
5	700	$250	$1,000	$1,250
6	780	$250	$1,200	$1,450
7	830	$250	$1,400	$1,650
8	860	$250	$1,600	$1,850
9	870	$250	$1,800	$2,050
10	860	$250	$2,000	$2,250
11	840	$250	$2,200	$2,450

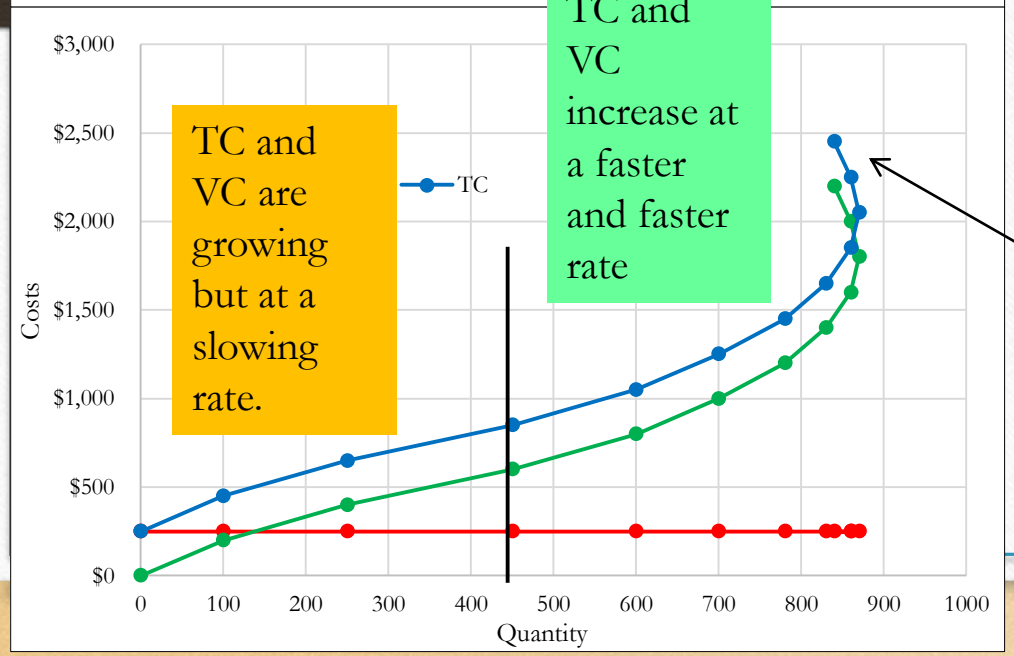
The shape of TC (and VC)



L	Q	FC	VC	TC
0	0	$250	$0	$250
1	100	$250	$200	$450
2	250	$250	$400	$650
3	450	$250	$600	$850
4	600	$250	$800	$1,050
5	700	$250	$1,000	$1,250
6	780	$250	$1,200	$1,450
7	830	$250	$1,400	$1,650
8	860	$250	$1,600	$1,850
9	870	$250	$1,800	$2,050
10	860	$250	$2,000	$2,250
11	840	$250	$2,200	$2,450



Basically, the negative MP$_L$ means that after nine workers if you hire more, they just take away from total product. Therefore, it is safe to assume that no rational business owner would hire more than 9 workers here. Because of this, many times that part is left off the production functions.



Up until three workers your production function grows at an increasing rate. That is when your total cost curve (and VC also) is increasing at a slowing rate.

After the third worker your production function grows at a slowing rate. That is when your total cost curve (and your VC) increases at an increasing rate.

After the ninth worker your production function DECREASES. That is when your total cost curve (and your VC) bends backward.

Practice –

TC, VC, FC

Production and Costs

Exercises

- We will calculate and graph costs for two other types of production functions.
- These will be the same production functions we worked with in Module 08e (slides 4 and 5).

Exercise 1: TC, VC, and FC of short-run production

L	Q	FC	VC	TC
0	0			
1	100			
2	190			
3	270			
4	330			
5	380			
6	420			
7	450			
8	470			
9	480			
10	485			

Let's say that this is the production table for your business' weekly operation.

What are your FC, VC and TC if your weekly costs are the following?

- You pay a weekly rent of $250 (you are obligated to pay this for a year)
- You pay each worker a weekly wage of $200 (they only work a few hours a day and you can hire & fire them as necessary)

Exercise 1: TC, VC, and FC of short-run production

L	Q	FC	VC	TC
0	0	$250	$0	
1	100	$250	$200	
2	190	$250	$400	
3	270	$250	$600	
4	330	$250	$800	
5	380	$250	$1,000	
6	420	$250	$1,200	
7	450	$250	$1,400	
8	470	$250	$1,600	
9	480	$250	$1,800	
10	485	$250	$2,000	

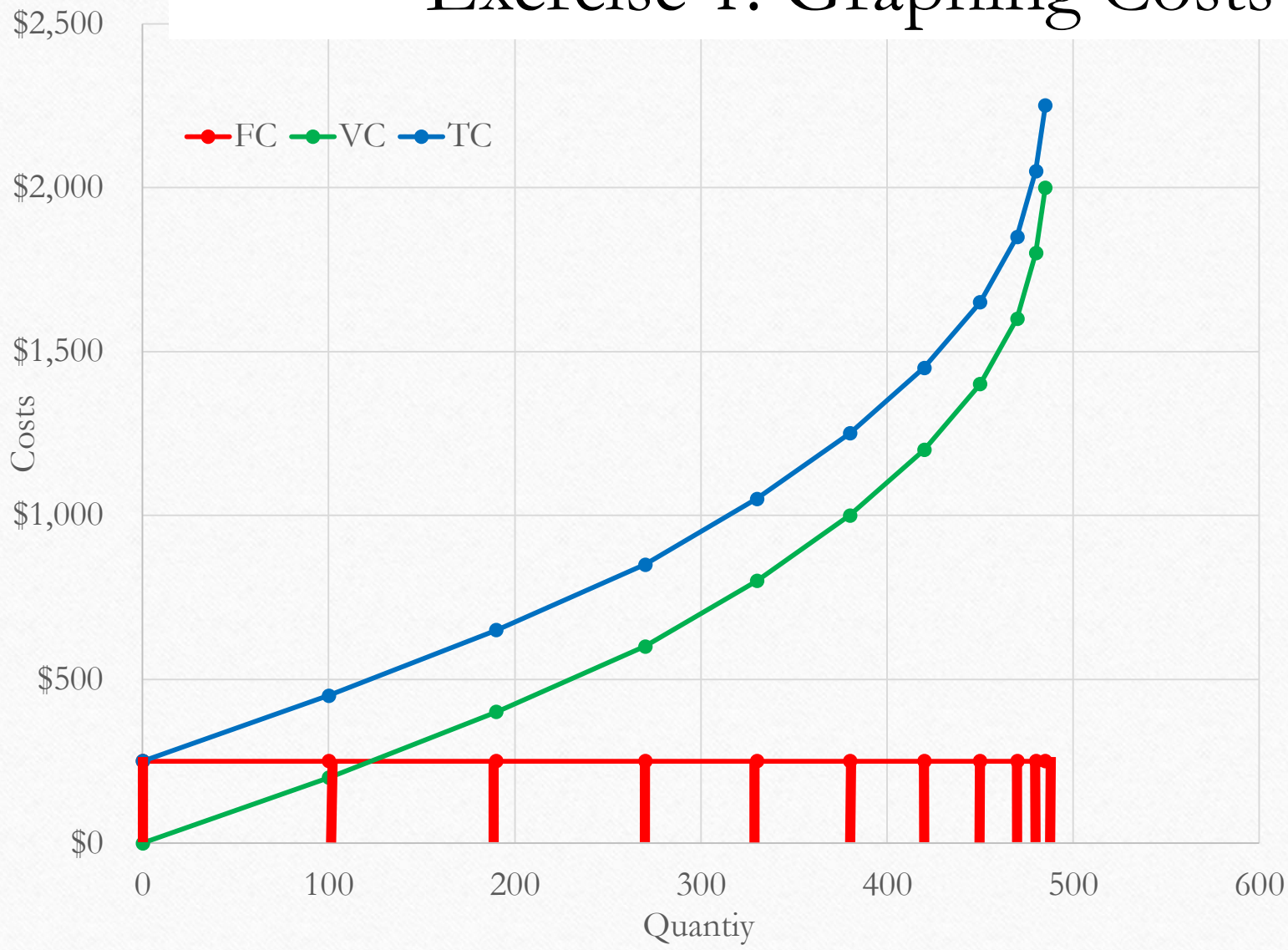
- The weekly rent of $250 is a Fixed Cost.
  - You have to pay this regardless of the output. You pay it even if Q=0, but you do not have to pay more for rent when your Q=480.
- The worker's wage of $200 is a Variable Cost
  - This **varies** with the level of production. When you produce nothing, you will fire your workers and pay $0, however, if you want to crank up production, you need to hire more workers.

Exercise 1: TC, VC, and FC of short-run production

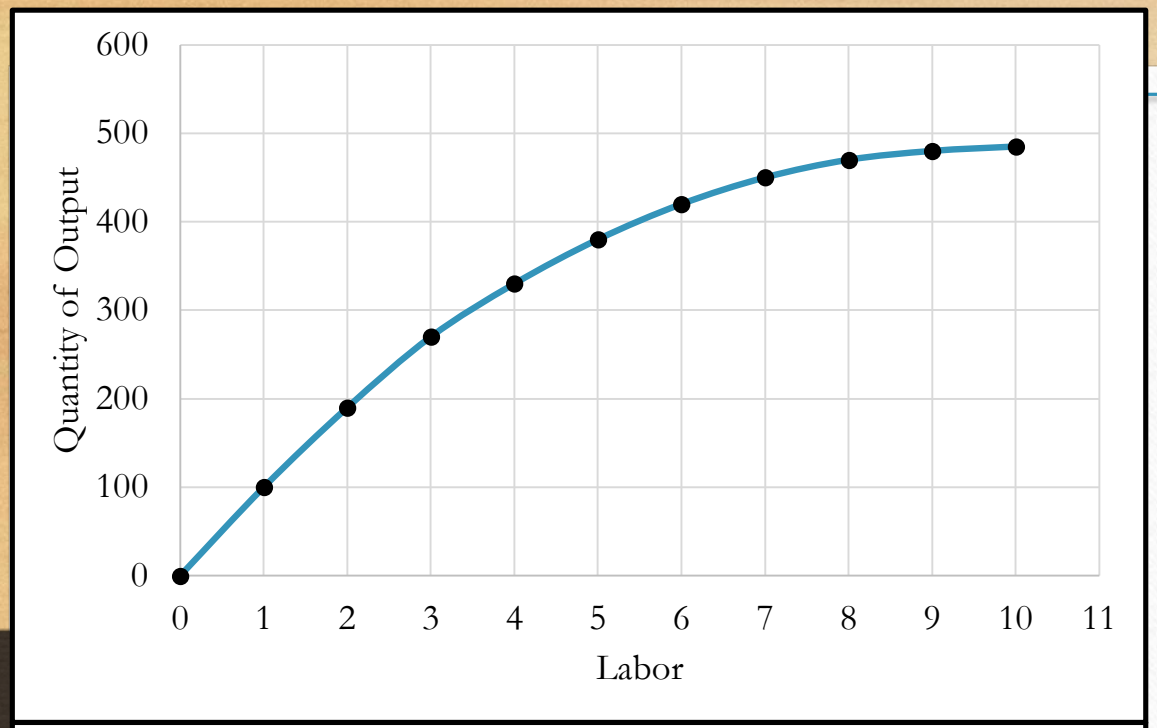
L	Q	FC	VC	TC
0	0	$250	$0	$250
1	100	$250	$200	$450
2	190	$250	$400	$650
3	270	$250	$600	$850
4	330	$250	$800	$1,050
5	380	$250	$1,000	$1,250
6	420	$250	$1,200	$1,450
7	450	$250	$1,400	$1,650
8	470	$250	$1,600	$1,850
9	480	$250	$1,800	$2,050
10	485	$250	$2,000	$2,250

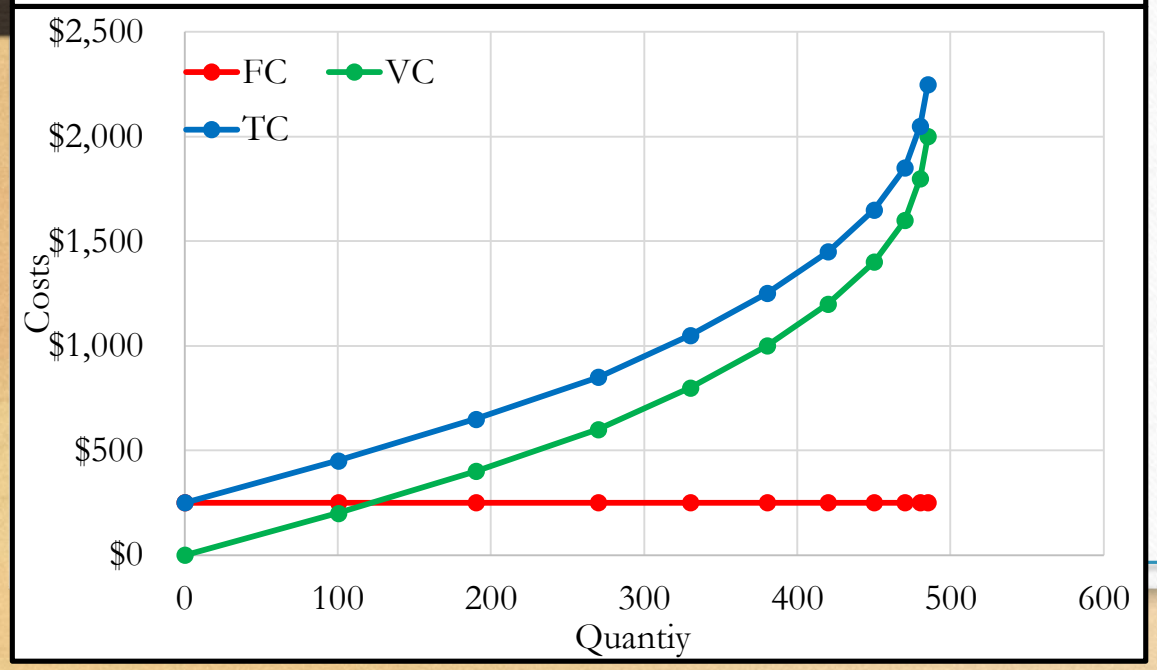
- Total Cost = Fixed Cost + Variable Cost.
- For instance, when production is 330 (which is obtained by having 4 workers) your fixed cost is $250, your variable cost is 4*$200=$800. The sum is $1,050.

Exercise 1: Graphing Costs



L	Q	FC	VC	TC
0	0	$250	$0	$250
1	100	$250	$200	$450
2	190	$250	$400	$650
3	270	$250	$600	$850
4	330	$250	$800	$1,050
5	380	$250	$1,000	$1,250
6	420	$250	$1,200	$1,450
7	450	$250	$1,400	$1,650
8	470	$250	$1,600	$1,850
9	480	$250	$1,800	$2,050
10	485	$250	$2,000	$2,250





Exercise 1: Conclusion

As you see in the graph for the production function, diminishing marginal product hits in right away. This means that the extra output we can produce by hiring one more worker is getting smaller and smaller.

The corresponding TC and VC is increasing faster and faster then.

Exercise 2: TC, VC, and FC of short-run production

L	Q	FC	VC	TC
0	0			
1	100			
2	200			
3	300			
4	400			
5	500			
6	600			
7	700			
8	800			
9	900			
10	1000			

Let's say that this is the production table for your business' weekly operation. What are your FC, VC and TC if your weekly costs are the following?

- You pay a weekly rent of $250 (you are obligated to pay this for a year)
- You pay each worker a weekly wage of $200 (they only work a few hours a day and you can hire & fire them as necessary)

Exercise 2: TC, VC, and FC of short-run production

L	Q	FC	VC	TC
0	0	$250	$0	
1	100	$250	$200	
2	200	$250	$400	
3	300	$250	$600	
4	400	$250	$800	
5	500	$250	$1,000	
6	600	$250	$1,200	
7	700	$250	$1,400	
8	800	$250	$1,600	
9	900	$250	$1,800	
10	1000	$250	$2,000	

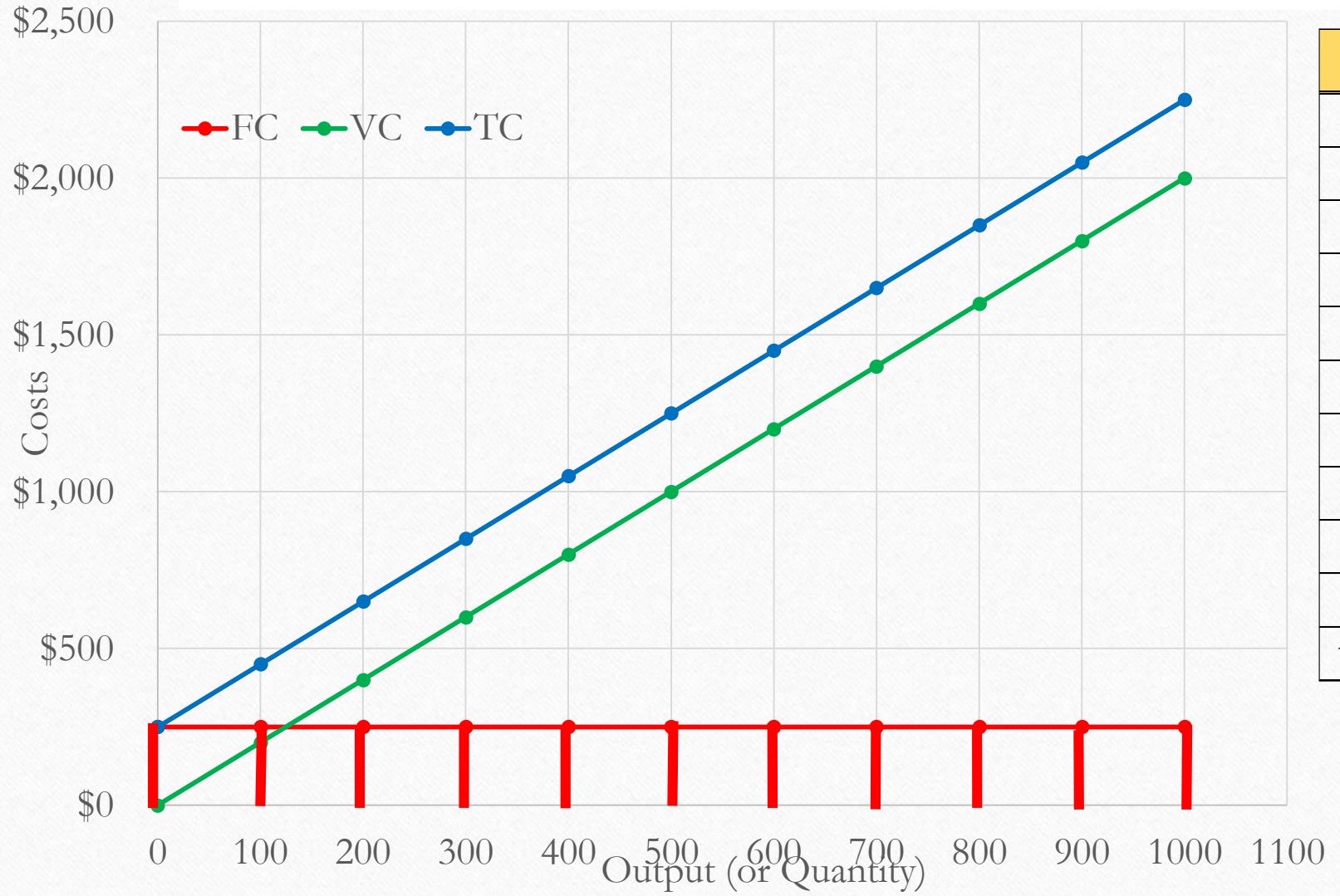
- The weekly rent of $250 is a Fixed Cost.
  - You have to pay this regardless of the output. You pay it even if Q=0, but you do not have to pay more for rent when your Q=1000.
- The worker's wage of $200 is a Variable Cost
  - This **varies** with the level of production. When you produce nothing, you will fire your workers and pay $0, however, if you want to crank up production, you need to hire more workers.

Exercise 2: TC, VC, and FC of short-run production

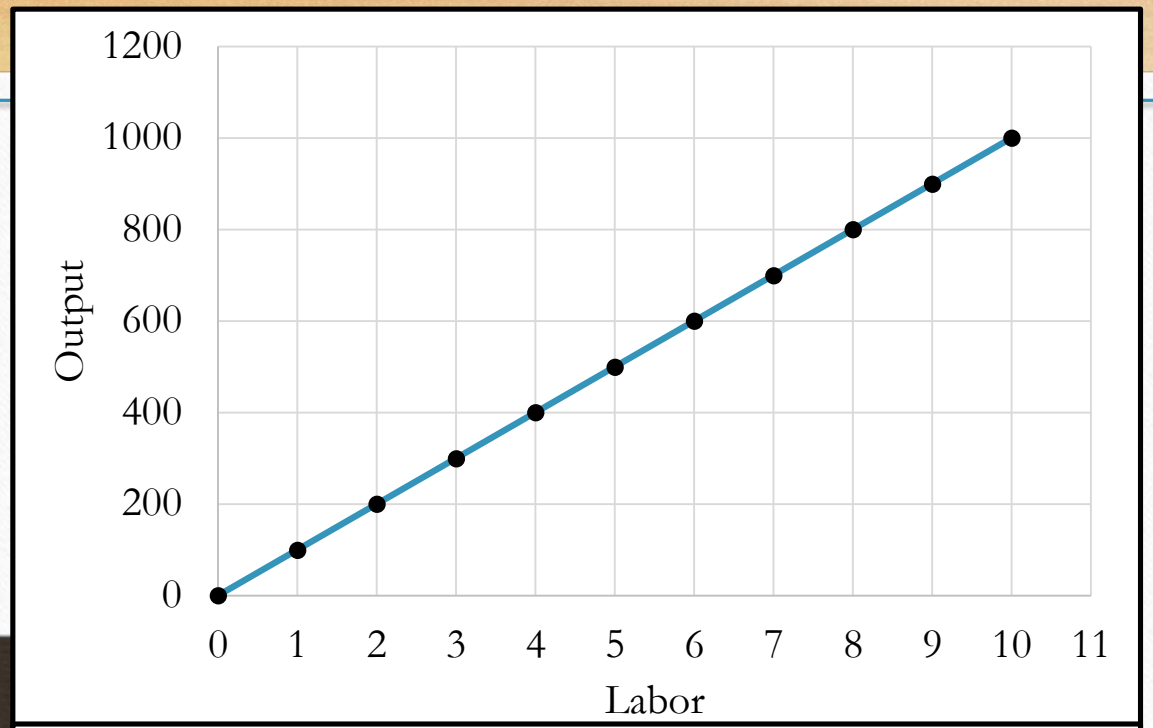
L	Q	FC	VC	TC
0	0	$250	$0	$250
1	100	$250	$200	$450
2	200	$250	$400	$650
3	300	$250	$600	$850
4	400	$250	$800	$1,050
5	500	$250	$1,000	$1,250
6	600	$250	$1,200	$1,450
7	700	$250	$1,400	$1,650
8	800	$250	$1,600	$1,850
9	900	$250	$1,800	$2,050
10	1000	$250	$2,000	$2,250

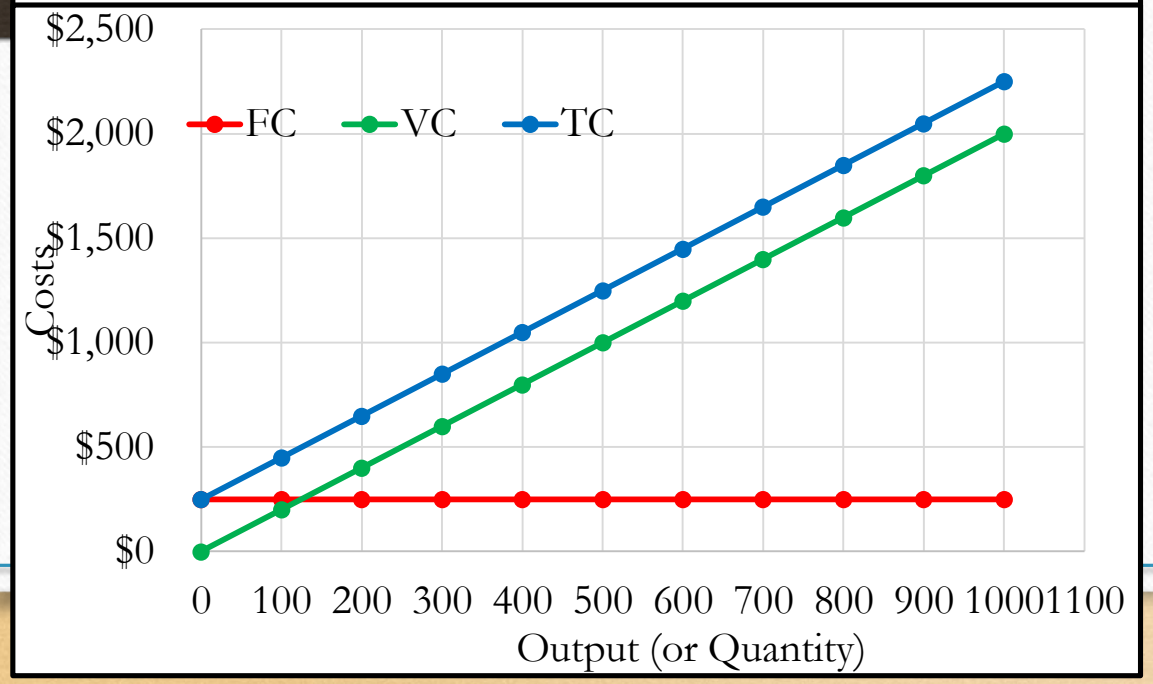
- Total Cost = Fixed Cost + Variable Cost.
- For instance, when production is 400 (which is obtained by having 4 workers) your fixed cost is $250, your variable cost is 4*$200=$800. The sum is $1,050.

Exercise 2: Graphing Costs



L	Q	FC	VC	TC
0	0	$250	$0	$250
1	100	$250	$200	$450
2	200	$250	$400	$650
3	300	$250	$600	$850
4	400	$250	$800	$1,050
5	500	$250	$1,000	$1,250
6	600	$250	$1,200	$1,450
7	700	$250	$1,400	$1,650
8	800	$250	$1,600	$1,850
9	900	$250	$1,800	$2,050
10	1000	$250	$2,000	$2,250





Exercise 2: Conclusion

As you see in the graph for the production function, marginal product is constant. This means that the extra output we can produce by hiring one more worker is the same throughout.

Therefore, the corresponding TC and VC curves are increasing at a constant rate.

Average and marginal costs

Production and Costs

Exercises

- We will calculate and graph costs for two other types of production functions.
- These will be the same production functions we worked with in Module 08e (slides 4 and 5).

Average Costs

- Average costs can be determined by dividing the firm's costs by the quantity of output produced.
- The average cost is the cost of each typical unit of product.
- Three types of average costs

Average Costs

- Average Total Costs (ATC) $ATC = \frac{TC}{Q}$ Cost of the typical unit produced
- Average Variable Costs (AVC) $AVC = \frac{VC}{Q}$ Variable cost of the typical unit
- Average Fixed Costs (AFC) $AFC = \frac{FC}{Q}$ Fixed cost of the typical unit
- Since TC=VC+FC, ATC=AVC+AFC

Average Costs

Q	FC	VC	TC	AFC = FC/Q	AVC = VC/Q	ATC = TC/Q
0	$250	$0	$250			
100	$250	$200	$450			
250	$250	$400	$650			
450	$250	$600	$850			
600	$250	$800	$1,050			
700	$250	$1,000	$1,250			
780	$250	$1,200	$1,450			
830	$250	$1,400	$1,650			
860	$250	$1,600	$1,850			
870	$250	$1,800	$2,050			
~~860~~	~~$250~~	~~$2,000~~	$2,250			
~~840~~	~~$250~~	$2,200	$2,450			

We know that business will not produce where the marginal product of labor is negative (where costs increase and output decrease at the same time) so we can forget about the last two rows of the table.

Average Fixed Costs

Q	FC	VC	TC	AFC = FC/Q	AVC = VC/Q	ATC = TC/Q
0	$250	$0	$250	-		
100	$250	$200	$450	$2.50		
250	$250	$400	$650	$1.00		
450	$250	$600	$850	$0.56		
600	$250	$800	$1,050	$0.42		
700	$250	$1,000	$1,250	$0.36		
780	$250	$1,200	$1,450	$0.32		
830	$250	$1,400	$1,650	$0.30		
860	$250	$1,600	$1,850	$0.29		
870	$250	$1,800	$2,050	$0.29		

When Q is zero, AFC does not exist. (We do not divide by 0).

$$\$0.56 = \frac{250}{450}$$

$$\$0.30 = \frac{250}{830}$$

Average Variable Costs

Q	FC	VC	TC	AFC = FC/Q	AVC = VC/Q	ATC = TC/Q
0	$250	$0	$250	-	-	
100	$250	$200	$450	$2.50	$2.00	
250	$250	$400	$650	$1.00	$1.60	
450	$250	$600	$850	$0.56	$1.33	
600	$250	$800	$1,050	$0.42	$1.33	
700	$250	$1,000	$1,250	$0.36	$1.43	
780	$250	$1,200	$1,450	$0.32	$1.54	
830	$250	$1,400	$1,650	$0.30	$1.69	
860	$250	$1,600	$1,850	$0.29	$1.86	
870	$250	$1,800	$2,050	$0.29	$2.07	

$$\$2.00 = \frac{\$200}{100}$$

$$\$1.43 = \frac{\$1,000}{700}$$

$$\$1.86 = \frac{\$1,600}{860}$$

Average Total Costs

Q	FC	VC	TC	AFC = FC/Q	AVC = VC/Q	ATC = TC/Q
0	$250	$0	$250	-	-	-
100	$250	$200	$450	$2.50	$2.00	$4.50
250	$250	$400	$650	$1.00	$1.60	$2.60
450	$250	$600	$850	$0.56	$1.33	$1.89
600	$250	$800	$1,050	$0.42	$1.33	$1.75
700	$250	$1,000	$1,250	$0.36	$1.43	$1.79
780	$250	$1,200	$1,450	$0.32	$1.54	$1.86
830	$250	$1,400	$1,650	$0.30	$1.69	$1.99
860	$250	$1,600	$1,850	$0.29	$1.86	$2.15
870	$250	$1,800	$2,050	$0.29	$2.07	$2.36

$$\$4.50 = \frac{\$450}{100}$$

$$\$1.79 = \frac{\$1,250}{700}$$

$$\$2.13 = \frac{\$1,850}{860}$$

Marginal Cost

- Marginal cost (MC) measures the amount total cost rises when the firm increases production by one unit.
- Marginal cost helps answer the following question:
  - How much does it cost to produce an additional unit of output?

$$MC = \frac{\Delta TC}{\Delta Q}$$

Marginal Cost

Q	FC	VC	TC	AFC = FC/Q	AVC = VC/Q	ATC = TC/Q	MC = ΔTC/ΔQ
0	$250	$0	$250	-	-	-	
100	$250	$200	$450	$2.50	$2.00	$4.50	$2.00
250	$250	$400	$650	$1.00	$1.60	$2.60	$1.33
450	$250	$600	$850	$0.56	$1.33	$1.89	$1.00
600	$250	$800	$1,050	$0.42	$1.33	$1.75	$1.33
700	$250	$1,000	$1,250	$0.36	$1.43	$1.79	$2.00
780	$250	$1,200	$1,450	$0.32	$1.54	$1.86	$2.50
830	$250	$1,400	$1,650	$0.30	$1.69	$1.99	$4.00
860	$250	$1,600	$1,850	$0.29	$1.86	$2.15	$6.67
870	$250	$1,800	$2,050	$0.29	$2.07	$2.36	$20.00

$$\$2.00 = \frac{\$450 - 250}{100 - 0}$$

$$\$1.33 = \frac{1{,}050 - 850}{600 - 450}$$

$$\$6.67 = \frac{1{,}850 - 1650}{860 - 830}$$

Practice – Average and Marginal Costs

Production and Costs

Some formulas to know

- TC=VC+FC, so VC=TC-FC and FC=TC-VC
- ATC=AVC+AFC therefore, AVC=ATC-AFC and AFC=ATC-AVC
- ATC=TC/Q, so TC=ATC*Q
- AFC=FC/Q, so FC=AFC*Q
- AVC=VC/Q, so VC=AVC*Q
- $MC = \frac{\Delta TC}{\Delta Q}$ OR $MC = \frac{\Delta VC}{\Delta Q}$

Find the number of that belongs in the green cell

Q	FC	VC	TC	AFC	AVC	ATC	MC
0	$100						
	100						
	100						
300	**100**		**550**			$1.8333	
400	**100**	**600**	**700**		$1.5000		**1.50**
	100						

FC=100 at all levels of production.

VC=AVC*Q (Since AVC=VC/Q)
So, when Q=400, VC=$1.5*400=$600

TC=VC+FC, so when Q=400, TC=700

TC=ATC*Q (Since ATC=TC/Q)
So, when Q=300,
TC=$1.8333*300=$550

Answer: $MC = \frac{\Delta TC}{\Delta Q} = \frac{700-550}{400-300} = \$1.50$

Find the number of that belongs in the green cell

Q	FC	VC	TC	AFC	AVC	ATC	MC
0			$80				
700		$800	X				
750			$980				$2.00

$$MC = \frac{\Delta TC}{\Delta Q} = \frac{980 - X}{750 - 700} = \$2.00$$

$$MC = \frac{\Delta TC}{\Delta Q} = \frac{980 - X}{50} = \$2.00$$

$$MC * \Delta Q = \Delta TC$$

$2.00*50=980-X

$100=980-X

X=$880

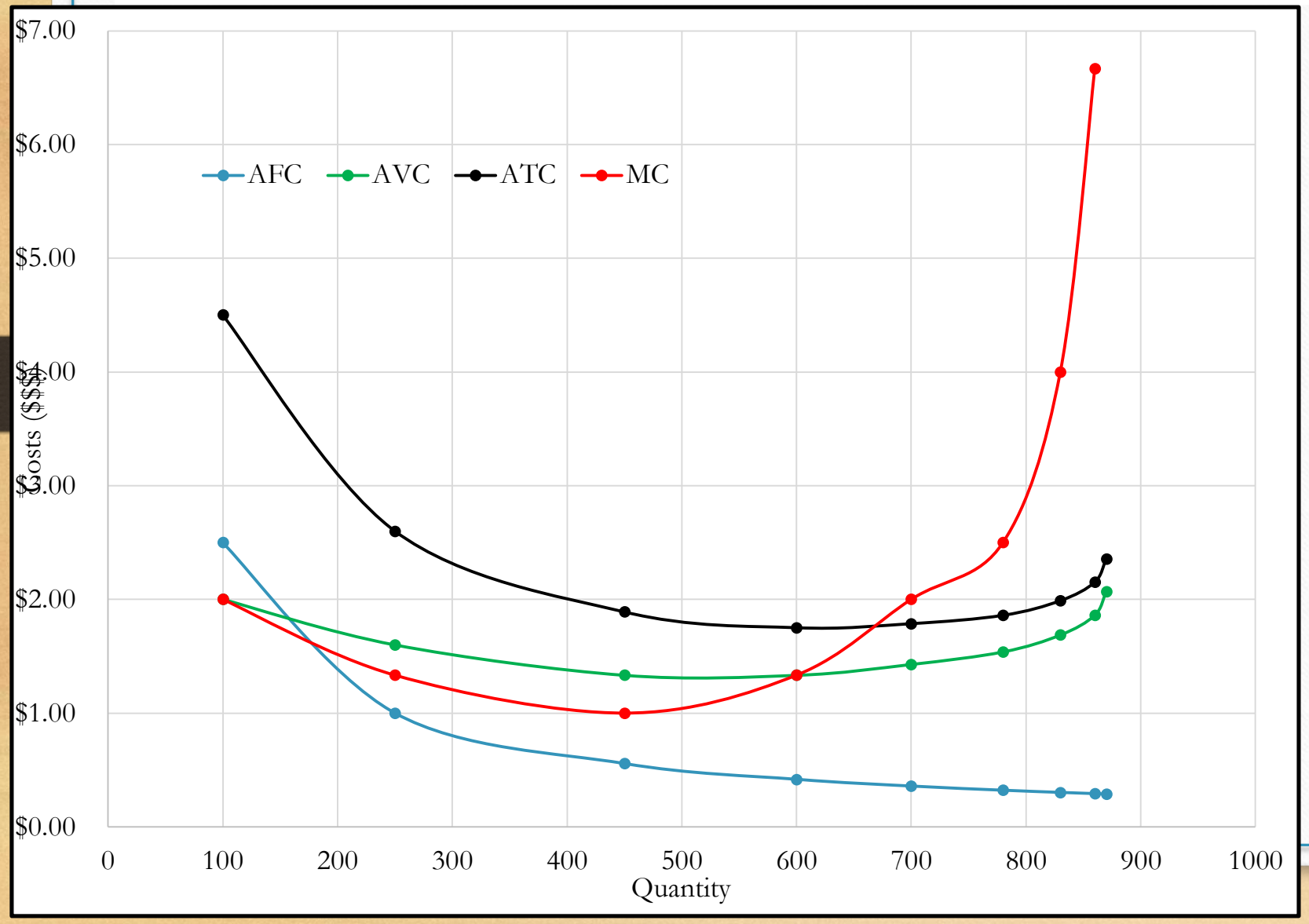
Graphing Average and Marginal Costs

Production and Costs

From the previous module

Q	FC	VC	TC	AFC = FC/Q	AVC = VC/Q	ATC = TC/Q	MC = ΔTC/ΔQ
0	$250	$0	$250	-	-	-	
100	$250	$200	$450	$2.50	$2.00	$4.50	$2.00
250	$250	$400	$650	$1.00	$1.60	$2.60	$1.33
450	$250	$600	$850	$0.56	$1.33	$1.89	$1.00
600	$250	$800	$1,050	$0.42	$1.33	$1.75	$1.33
700	$250	$1,000	$1,250	$0.36	$1.43	$1.79	$2.00
780	$250	$1,200	$1,450	$0.32	$1.54	$1.86	$2.50
830	$250	$1,400	$1,650	$0.30	$1.69	$1.99	$4.00
860	$250	$1,600	$1,850	$0.29	$1.86	$2.15	$6.67
870	$250	$1,800	$2,050	$0.29	$2.07	$2.36	$20.00

Graphing Average and Marginal Costs



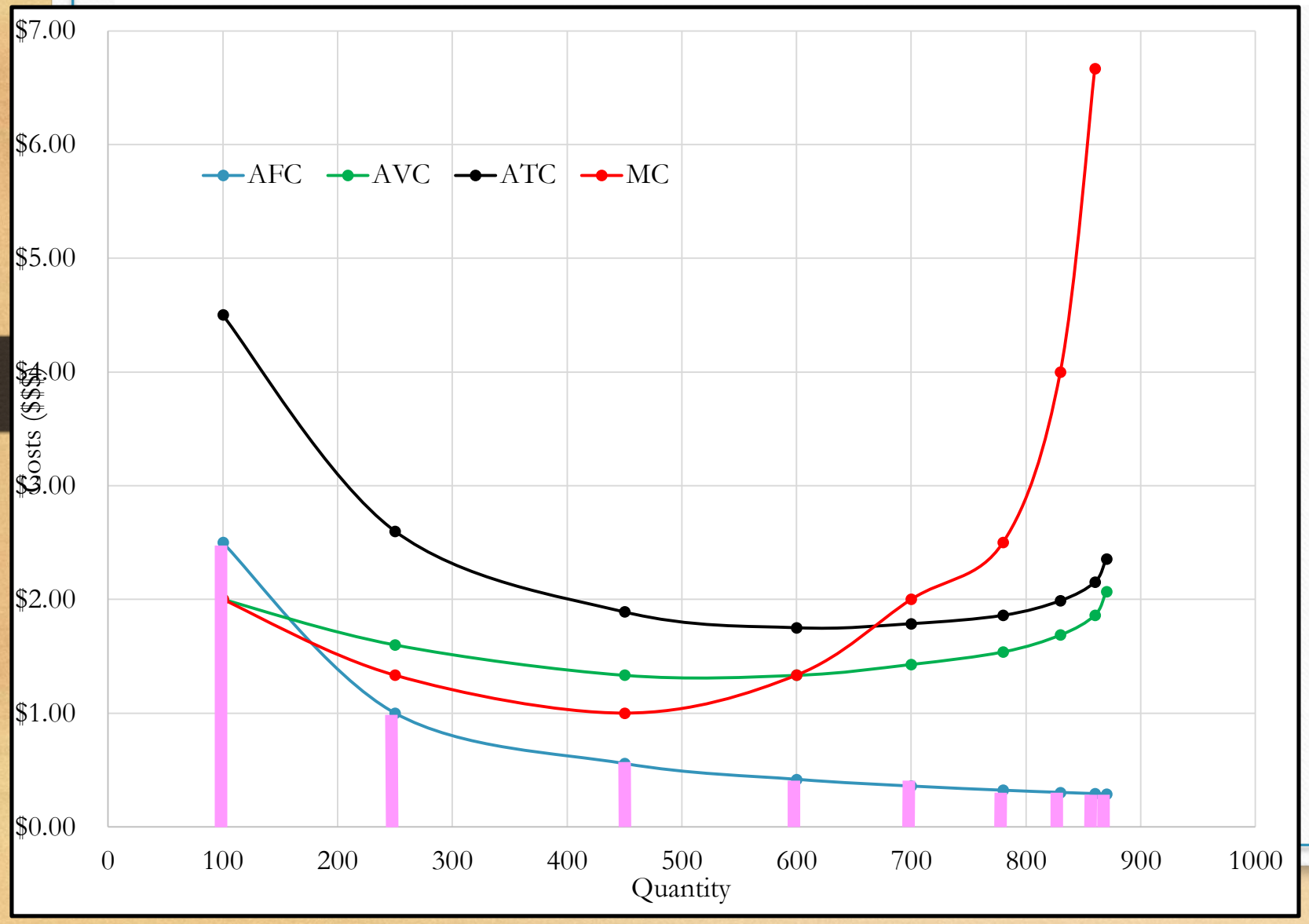
AFC decreases as Q increases. This is because as we produce more, the Fixed Cost gets divided by a larger and larger Q.

AVC is U-shaped

ATC is also U-shaped.

MC intersects AVC where AVC reaches its minimum. MC also intersects ATC where ATC reaches its minimum.

Further characteristics of average and marginal costs



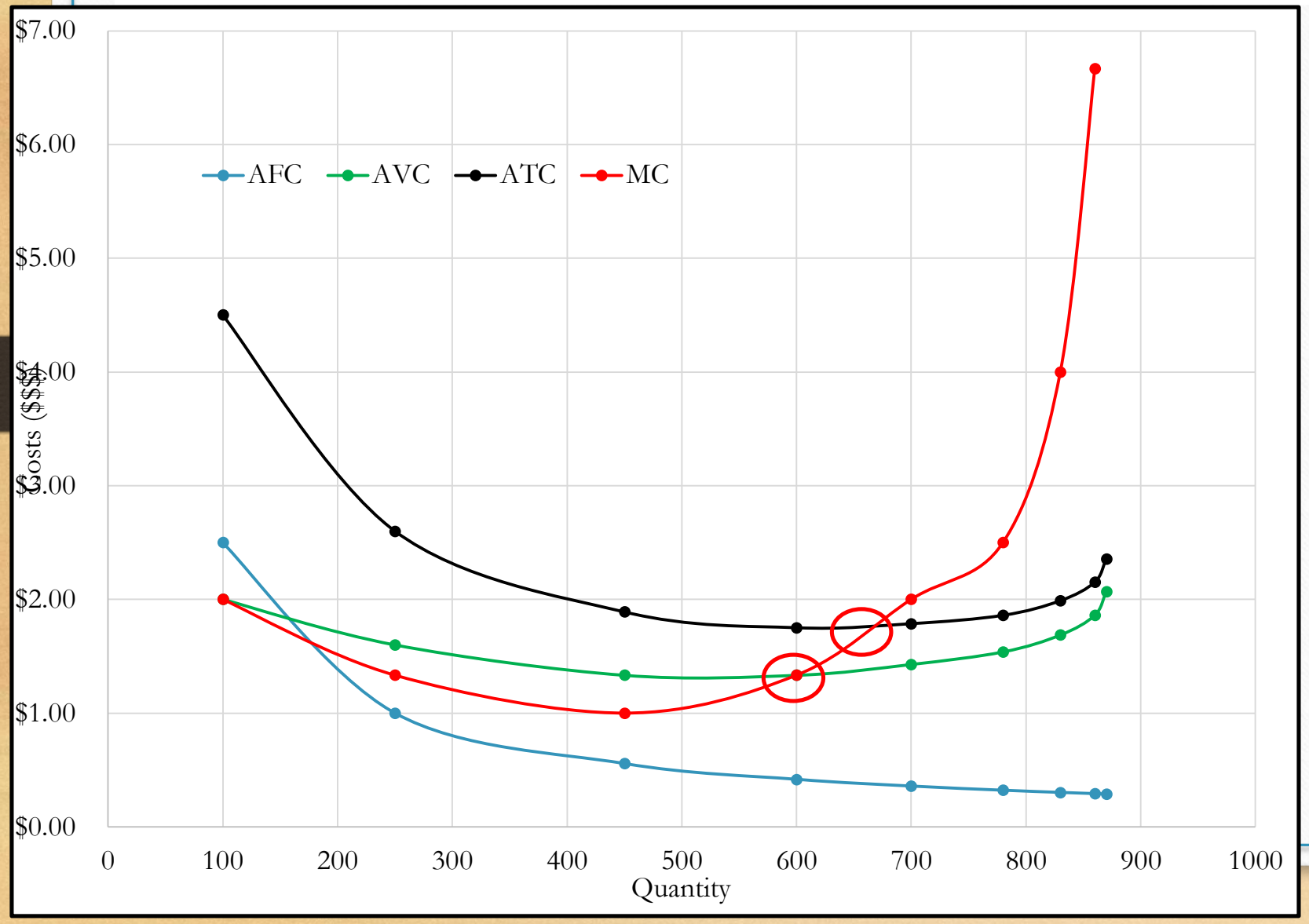
ATC is always above the AVC, but the vertical distance gets smaller and smaller as Q increases.

WHY?

The purple lines are the height of AFC.

The vertical distance between ATC and AVC is the AFC. As Q increases, ATC and AVC gets closer together, because AFC decreases.

Further characteristics of average and marginal costs



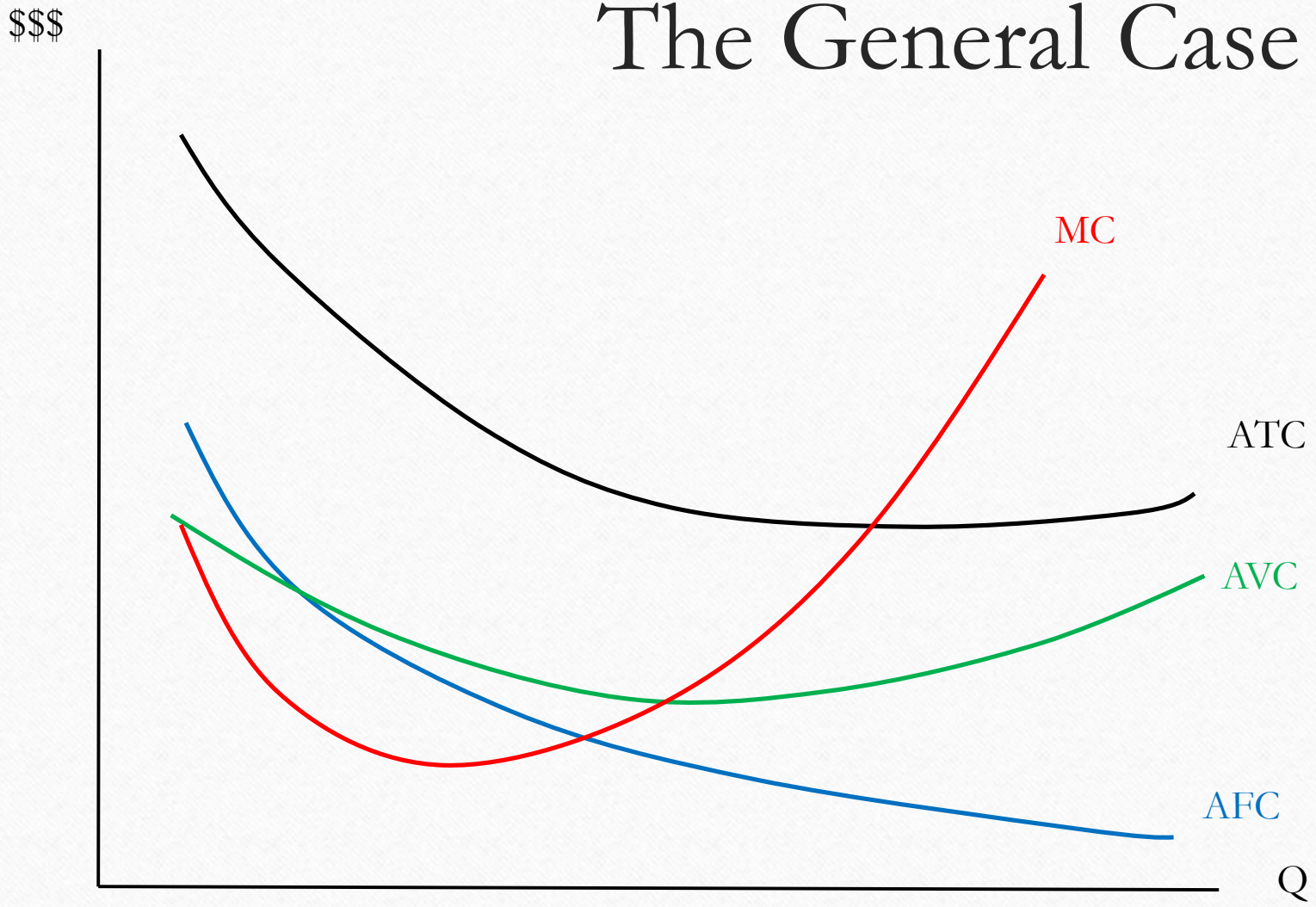
MC goes through AVC where AVC has its minimum.

MC goes through ATC where ATC has its minimum point.

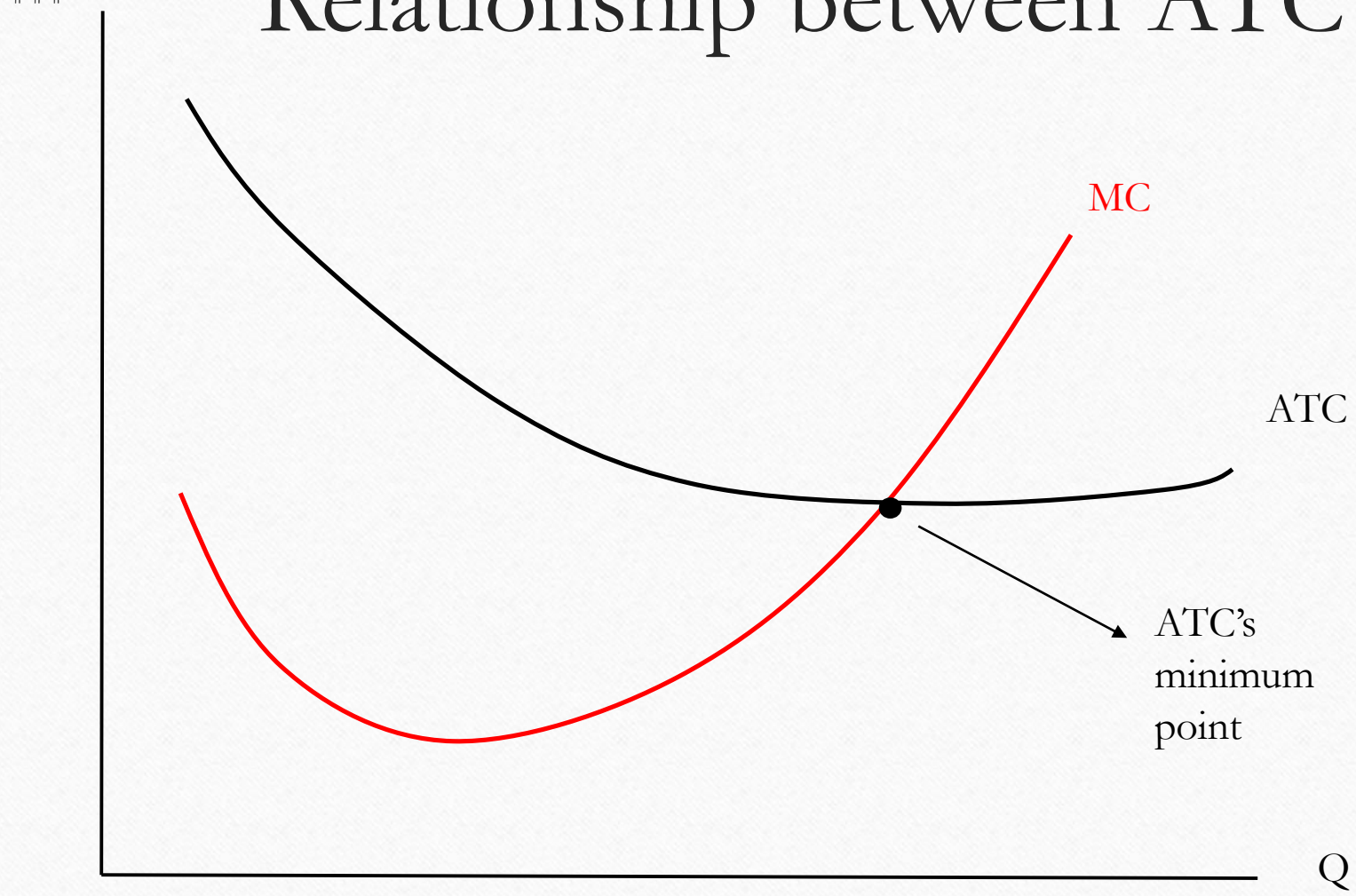
The General Case

- We will many times identify a firm by its costs, especially the average cost and marginal cost curves.
- A business operation can be characterized by the costs.
- Because of that we will show general cost curves.

The General Case



Relationship between ATC and MC



When MC is below ATC, ATC is decreasing.

When MC is above ATC, ATC is increasing.

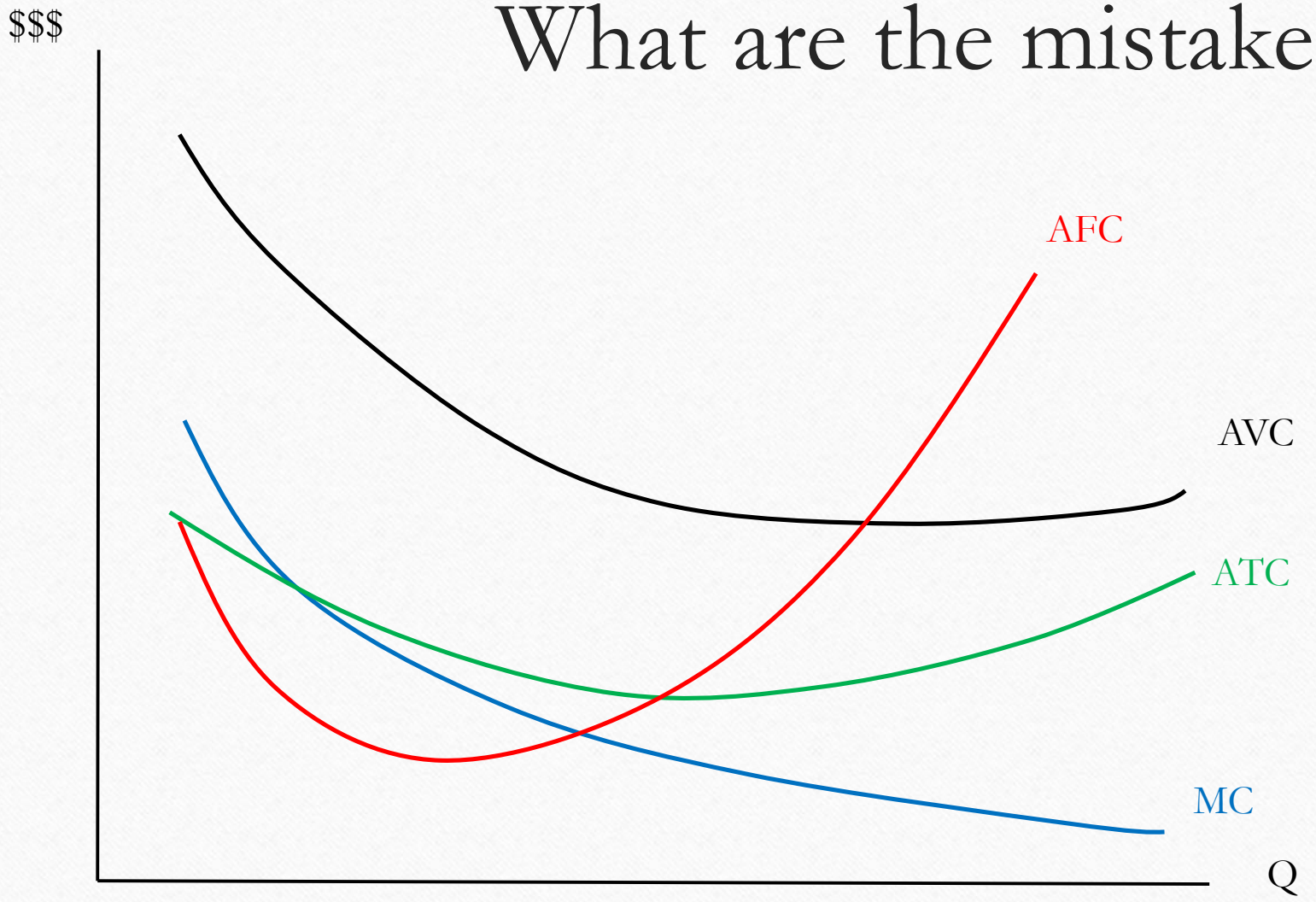
Summary of findings

- AFC decreases as Q increases.
- AVC and ATC are U-shaped (in the general case)
- MC intersects AVC and ATC at their minimum points.
- ATC is always above the AVC, but the vertical distance gets smaller and smaller as Q increases.

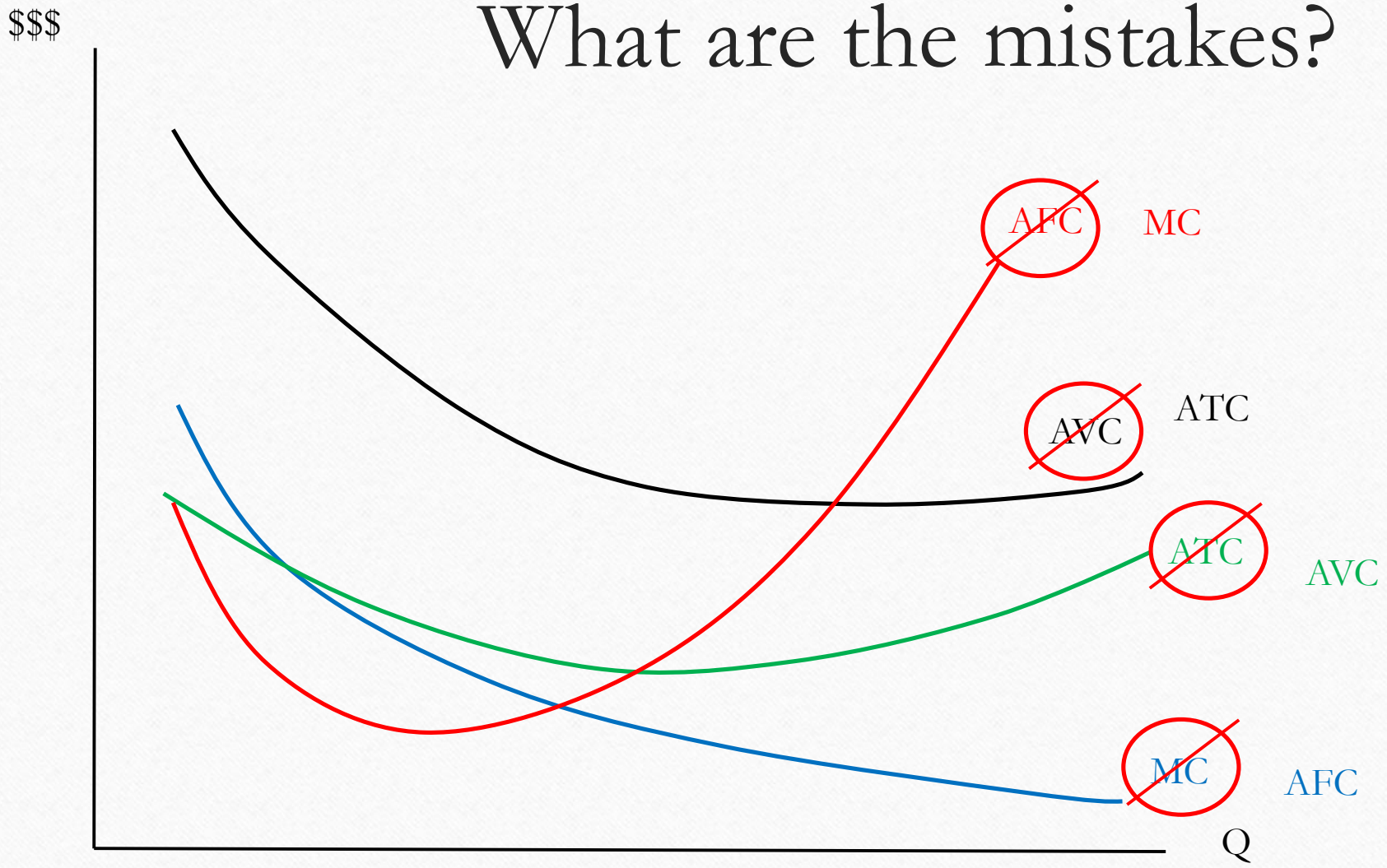
Practice – Graphs of Average and Marginal Costs

Production and Costs

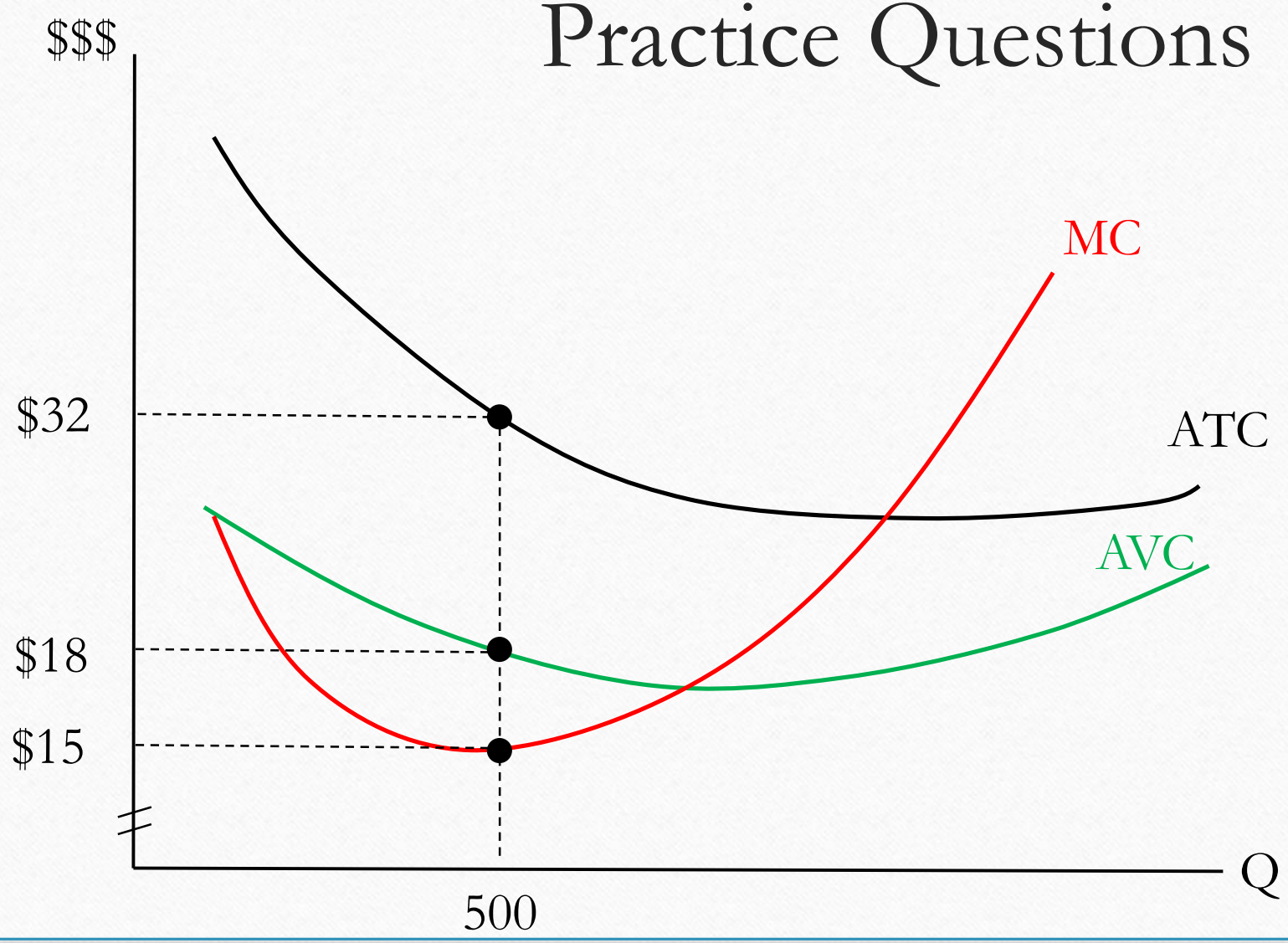
What are the mistakes?



What are the mistakes?



Practice Questions



Questions at Q of 500:

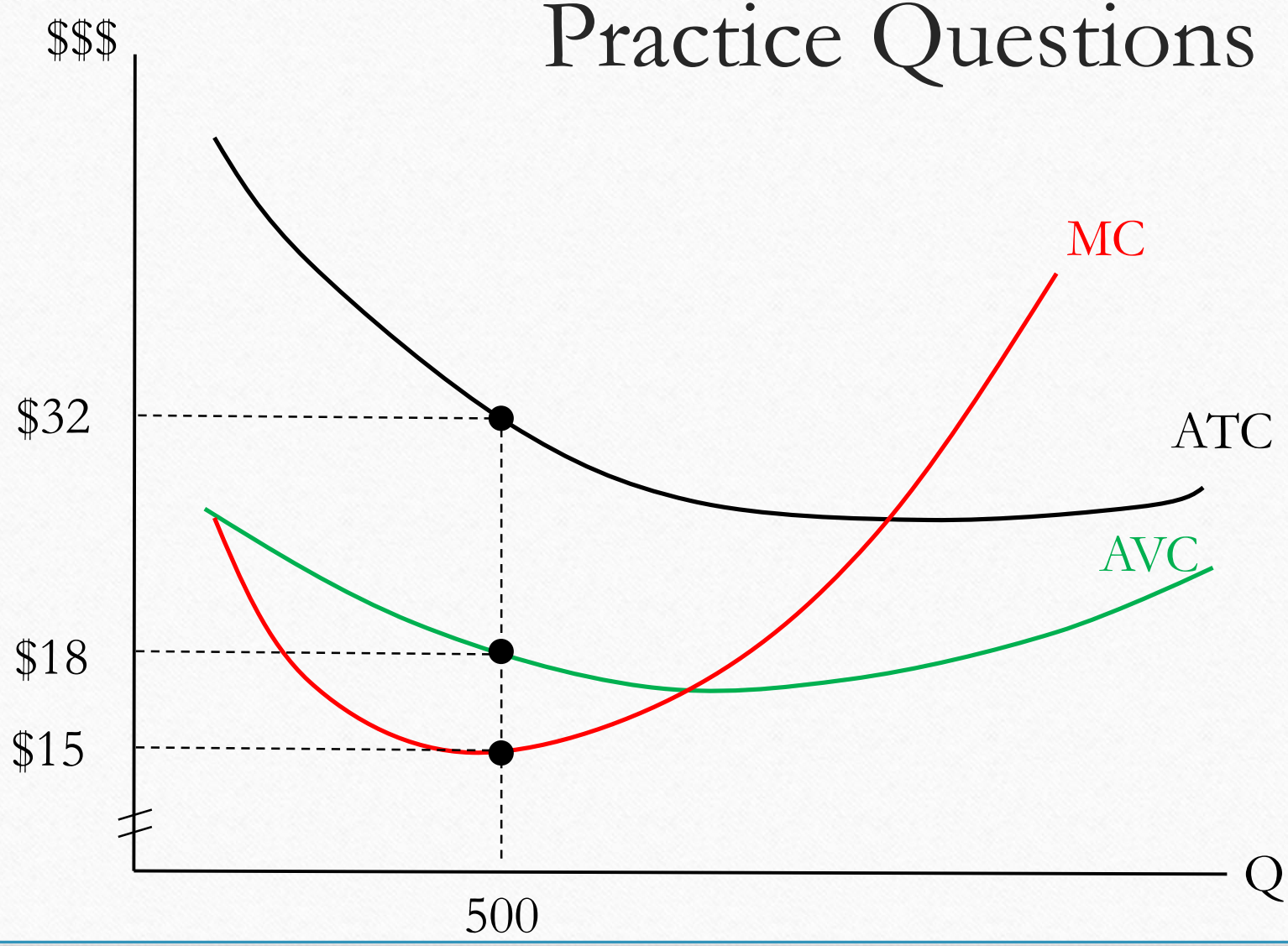
1) What is MC?

2) What is Total Cost?

3) What is Variable Cost?

4) What is Fixed Cost?

Practice Questions



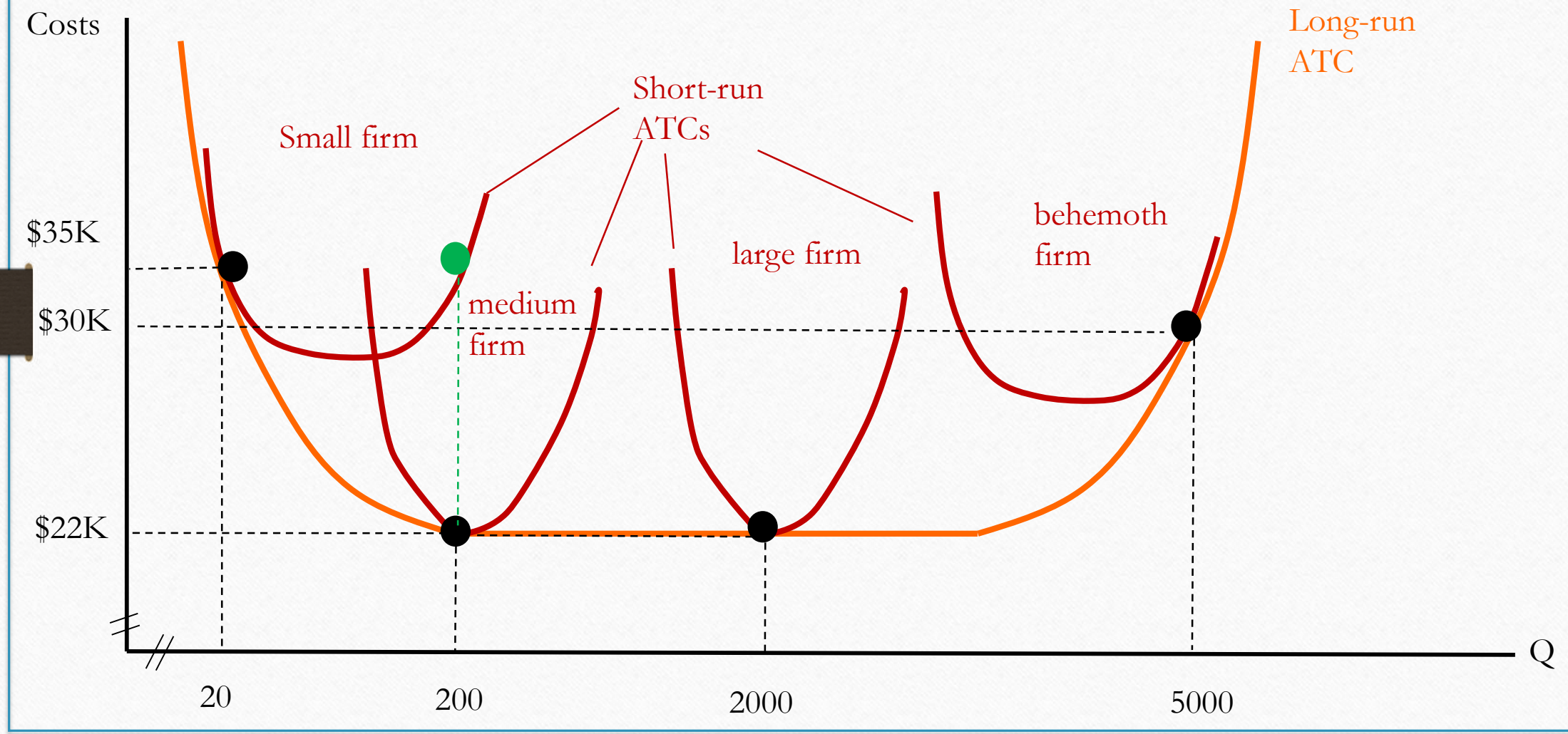
Questions at Q of 500:

1) What is MC?
   Answer: $15
2) What is Total Cost?
   Answer: $16,000
3) What is Variable Cost?
   Answer: $9,000
4) What is Fixed Cost?
   Answer: $7,000

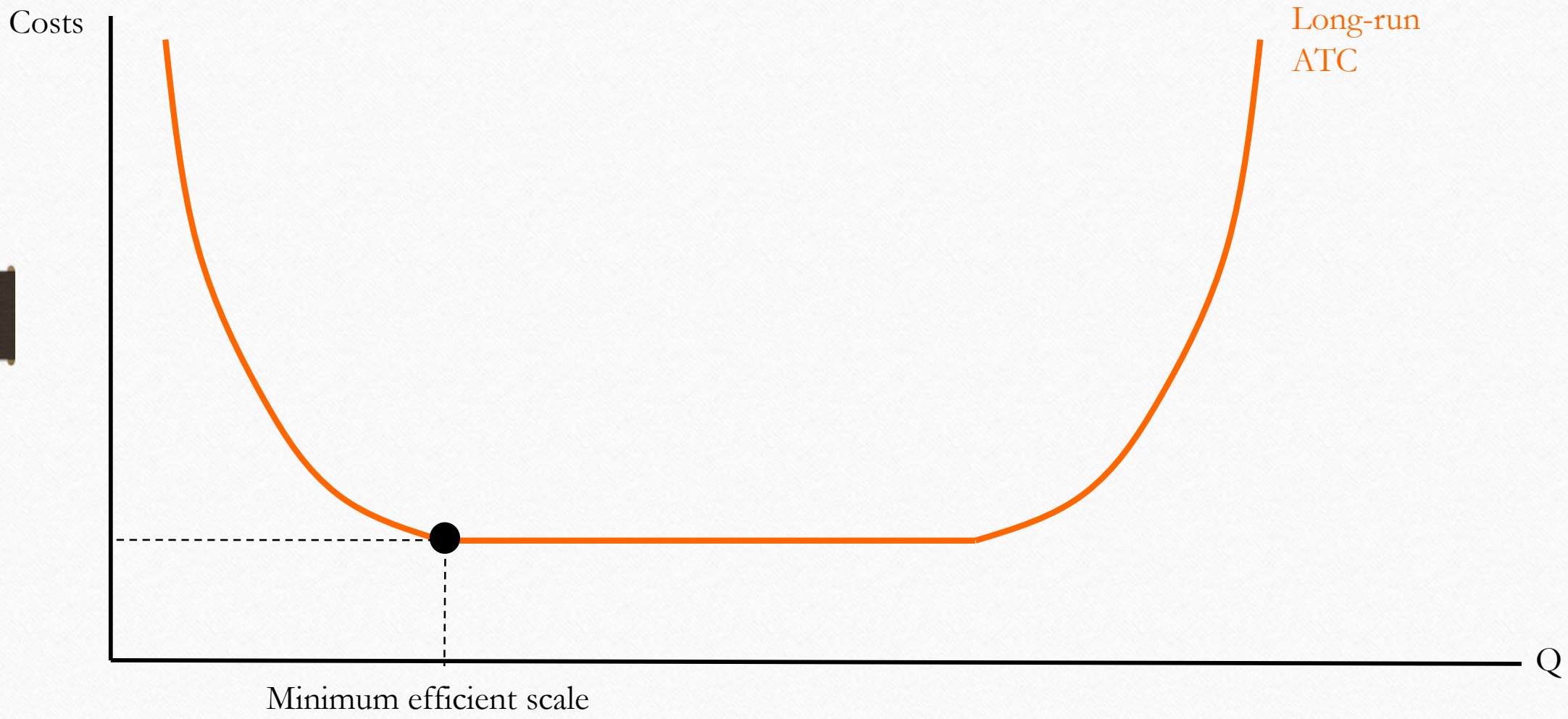
Long run Average Costs

Production and Costs

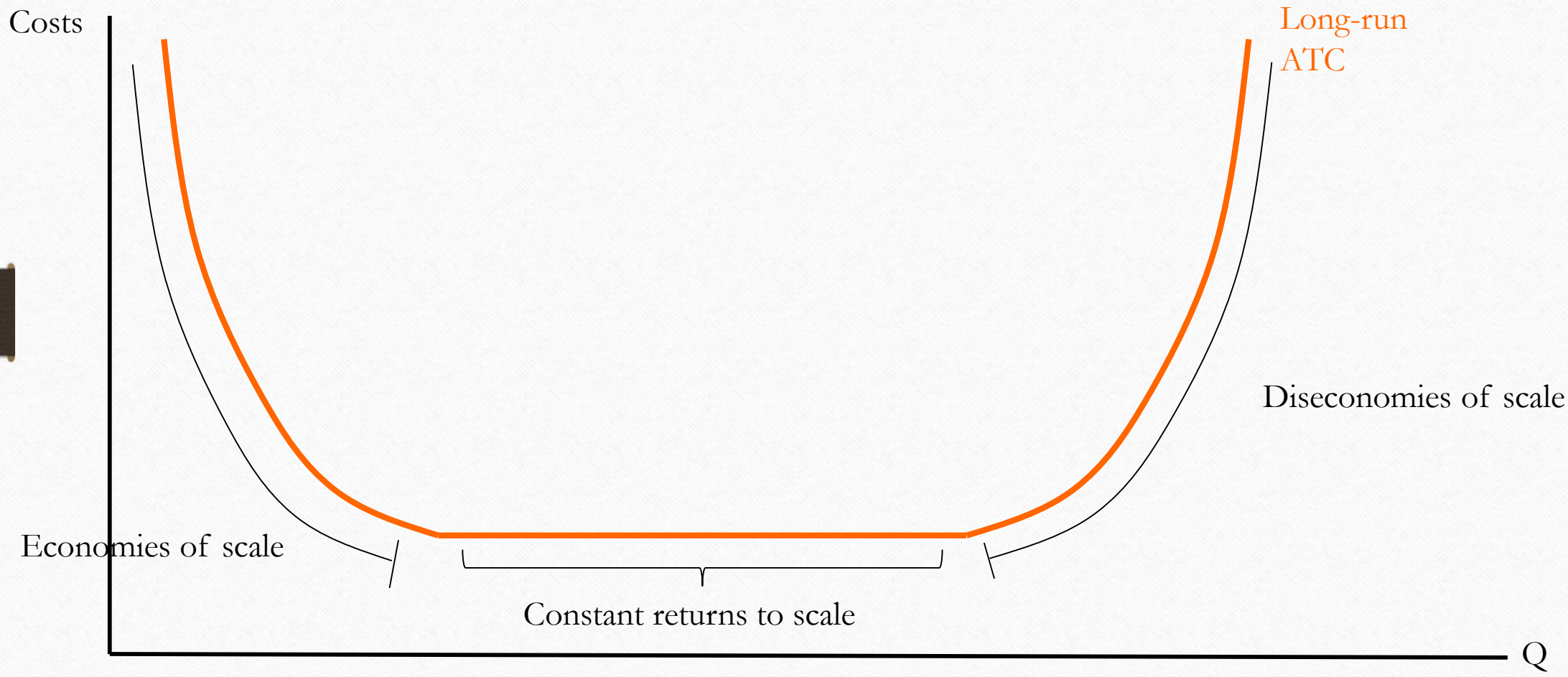
Costs of a car production company



Costs of a car production company



Long-run ATC


Costs
Long-run ATC
Diseconomies of scale
Economies of scale
Constant returns to scale
Q

Long run average total cost curve

Economies of scale The situation in which a firm's long-run average total costs fall as the firm increases output.

Constant returns to scale The situation in which a firm's long-run average total costs remain unchanged as it increases output.

Minimum efficient scale The level of output at which all economies of scale are exhausted.

Diseconomies of scale The situation in which a firm's long-run average total costs rise as the firm increases output.