Chapter 13 The Costs of Production

- The economic goal of every firm is to maximize its profits.

Total Revenue, TR

- The amount a firm receives for the sale of its output.

Total Cost, TC

- The market value of the inputs a firm uses in production.

- Profit, Π, is the firm's total revenue minus its total cost.

$$\text{Profit} = \text{Total revenue} - \text{Total cost}$$

$$\Pi = TR - TC$$

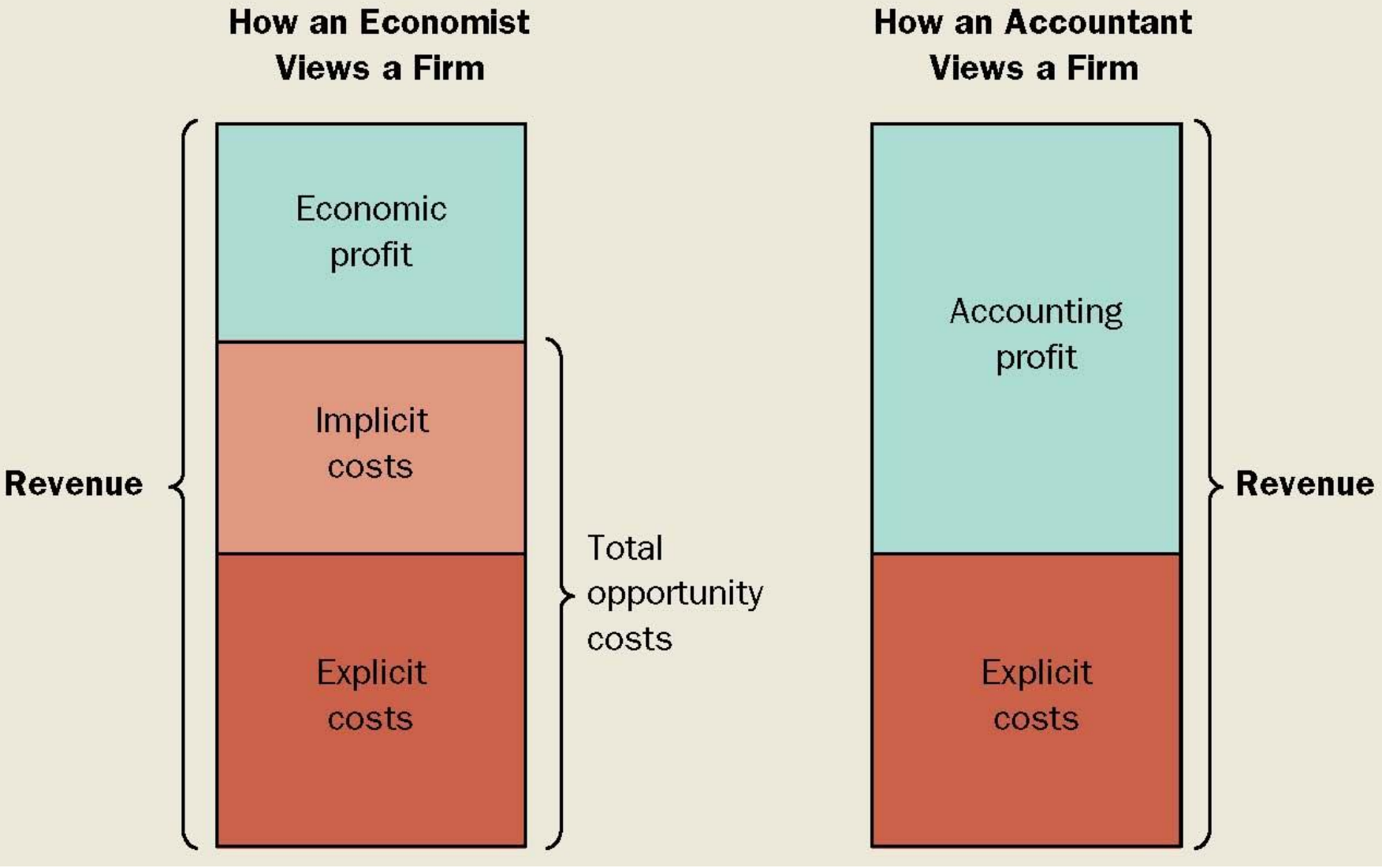
- A firm's cost of production includes all the opportunity costs of making its output of goods and services.

Explicit and Implicit Costs

- A firm's cost of production include explicit costs and implicit costs.
- Explicit costs are input costs that require a direct outlay of money by the firm (you have a bill for your accountant).
- Implicit costs are input costs that do not require an outlay of money by the firm (like the money you could have earned investing instead of updating your assembly line) – that is, opportunity costs.

- Economists measure a firm's economic profit as total revenue minus total cost, including both explicit and implicit costs, i.e., total opportunity costs.
- Accountants measure the accounting profit as the firm's total revenue minus only the firm's explicit costs.

- When total revenue exceeds both explicit and implicit costs, the firm earns economic profit.
- Economic profit is smaller than accounting profit because it includes implicit costs.


How an Economist Views a Firm
Economic profit
Implicit costs
Explicit costs
Revenue
Total opportunity costs
How an Accountant Views a Firm
Accounting profit
Explicit costs
Revenue

The Production Function

- The production function shows the relationship between quantity of inputs used to make a good and the quantity of output of that good.

- Let's do an example:

Jerry's TV Inc.

- Jerry's TV assembles plasma televisions.
- There is only one input to production – labour.

- Jerry's production function is given below.
- L = number of workers
- Q = quantity of TVs assembled per week

Jerry's Production Function

L	Q
0	0
10	50
20	120
30	150
40	170
50	180
60	170

Notice:

- Output increases as Jerry adds workers, but after the 20th worker, it does so at a decreasing rate.
- Each additional group of workers adds to total output, but each one adds less than the previous group.
- The 6th group of workers actually takes away from total output!

Marginal Product

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

$$\textbf{MP} = \frac{\textbf{change in total output}}{\textbf{change in \# of inputs}} = \frac{\triangle \textbf{Q}}{\triangle \textbf{L}}$$

*We use L here because it's our only input.

- Marginal product is the rate of change in total product from a small change in inputs.
- In other words, MP is the slope of the total product function.
- Now let's calculate Jerry's MP:

L	Q	MP = △Q/△L
0	0	
10	50	5
20	120	7
30	150	3
40	170	2
50	180	1
60	170	-1

Notice: the MP of the workers gets smaller as Jerry adds workers. We call this feature of production:

Diminishing Marginal Product

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

- For example, when Jerry hires the first 10 workers, they each add 5 TVs to his total output.
- When he hires the next 10, they each add 7 TVs to his total output.
- The next 10 workers he hires each add 3 TVs to total output (and so on…)

Why diminishing MP?

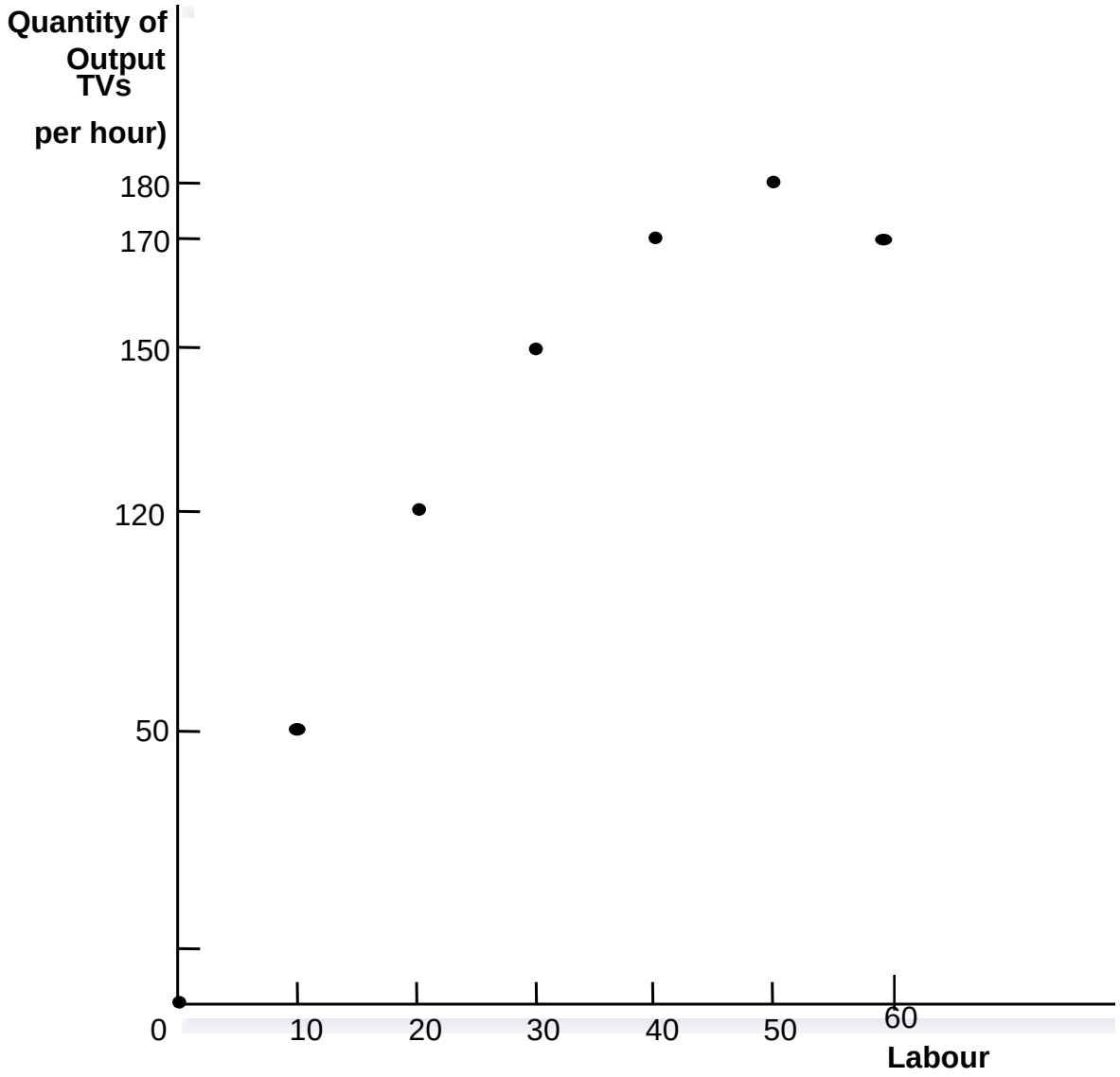
- Could be that too many workers get in each other's way.
- May not be enough work for everyone at the same time.
- Anything that could make workers less productive than if there were fewer of them.

- We often refer to diminishing MP as diminishing returns to an input.

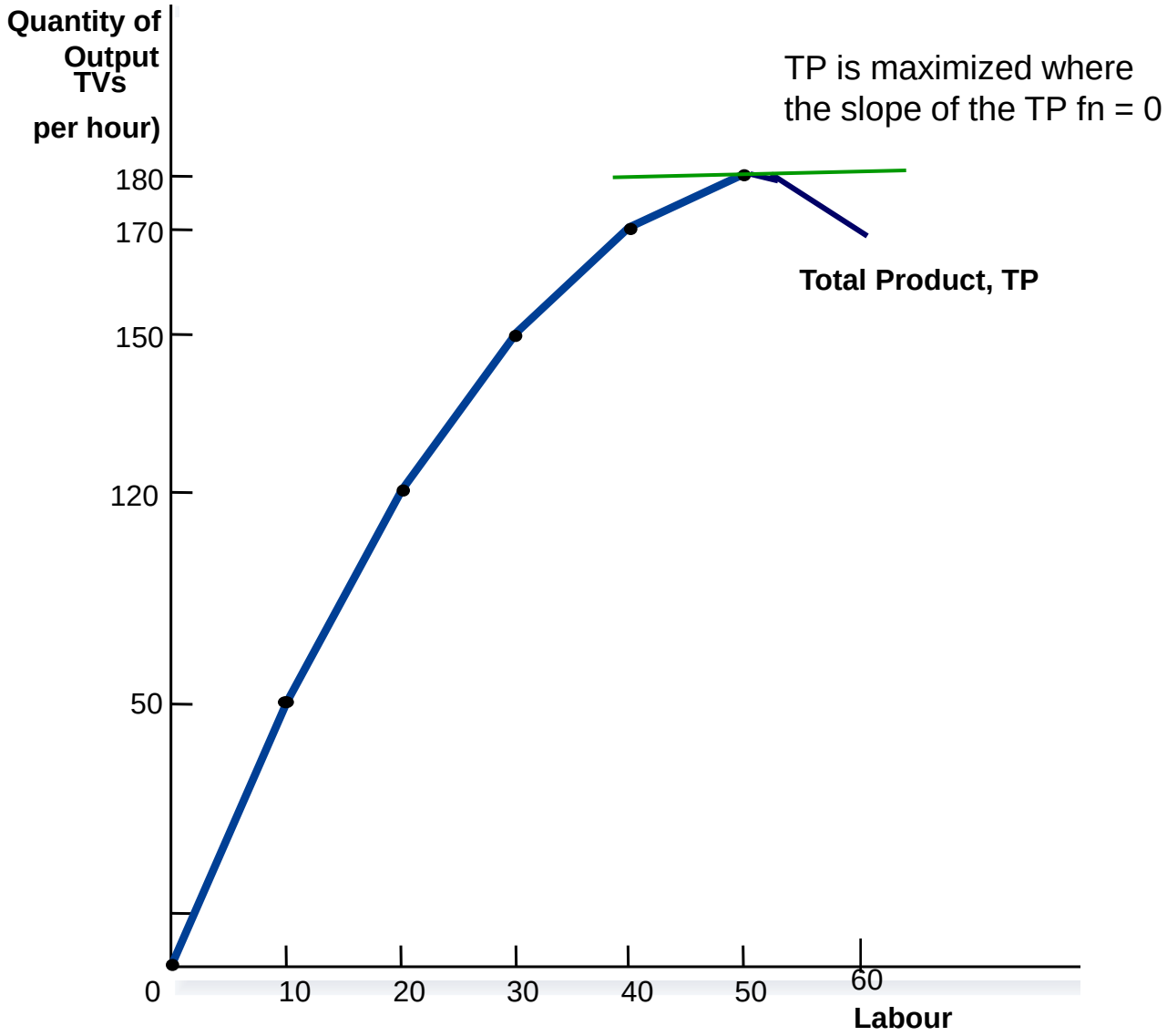
- In our example, we have diminishing returns to labour.

Now, let's graph Jerry's production function:

Jerry's Production Function



Jerry's Total Product Function



- Notice that TP is maximized when the slope of the TP function is zero.
- Since the slope of the TP function is MP,

TP is maximized when MP = 0

Also related to production is the concept of

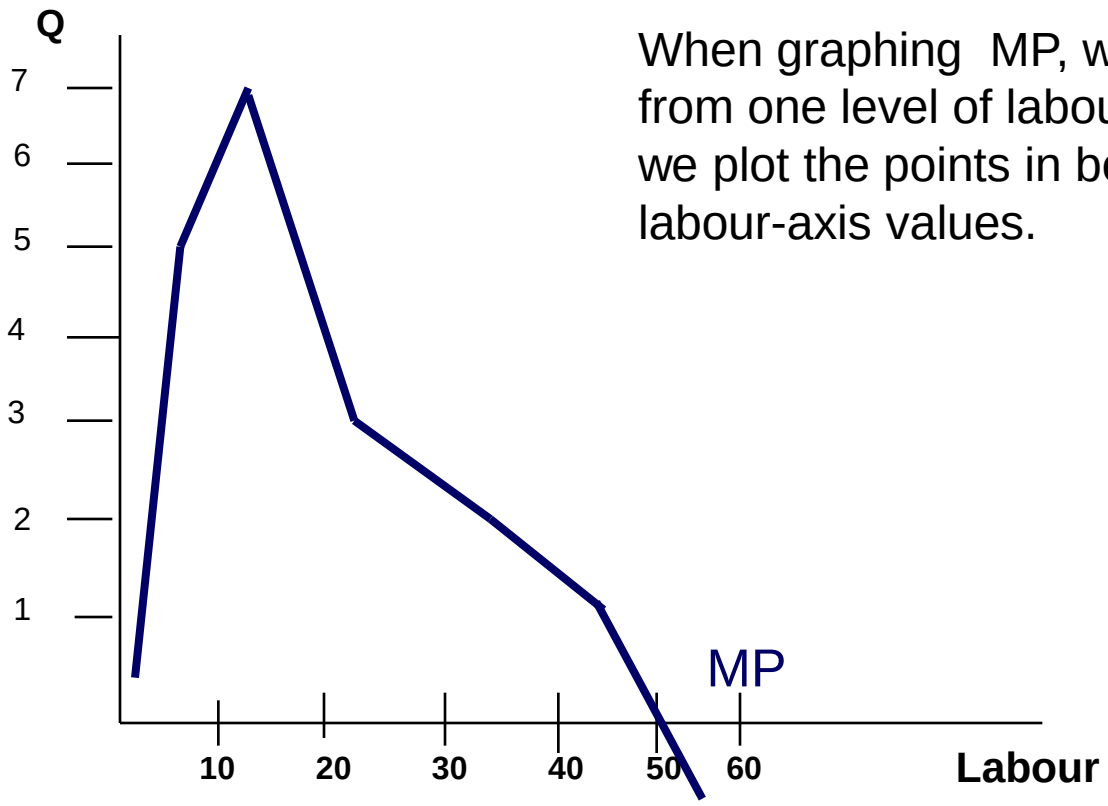
Average Product, AP $= \dfrac{\mathbf{Q}}{\mathbf{\#\ of\ inputs}}$

- AP tells us the quantity of output per input, in our case, Jerry's labour.
- AP will also diminish at some point.

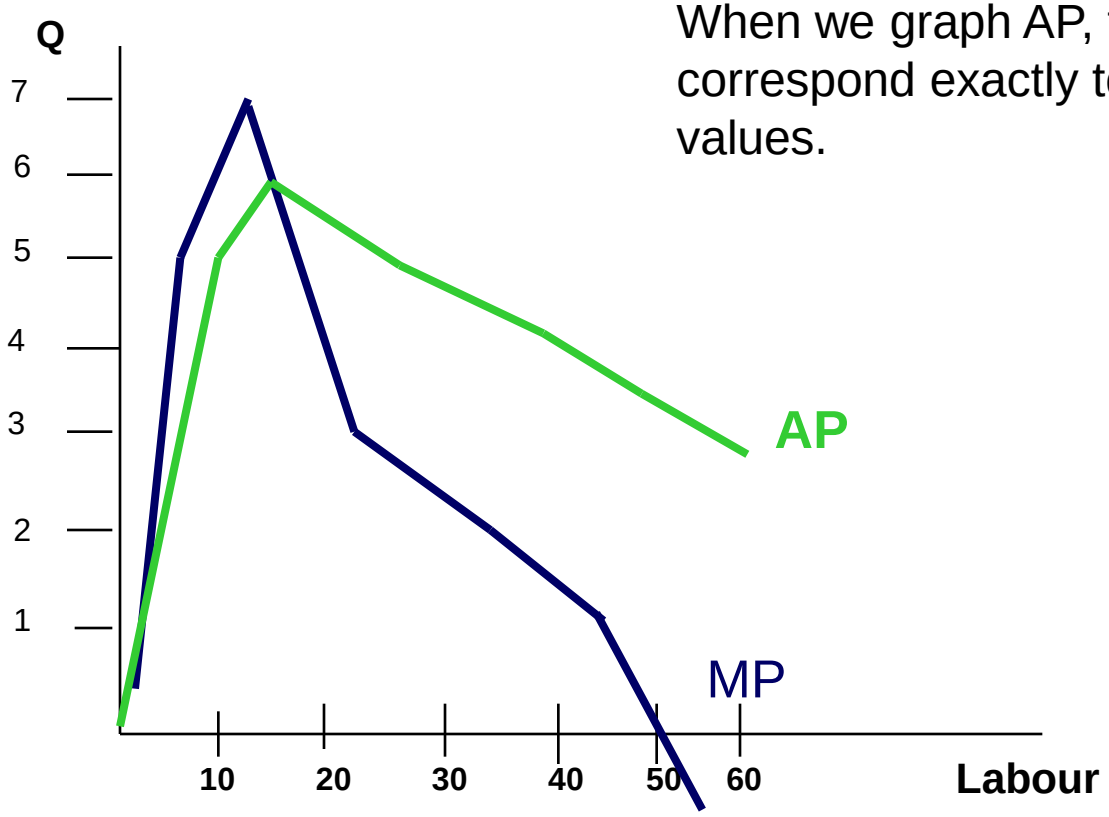
- Let's calculate it:

L	Q	MP = △Q/△L	AP = Q/L
0	0		0
10	50	5	5
20	120	7	6
30	150	3	5
40	170	2	4.25
50	180	1	3.6
60	170	-1	2.8

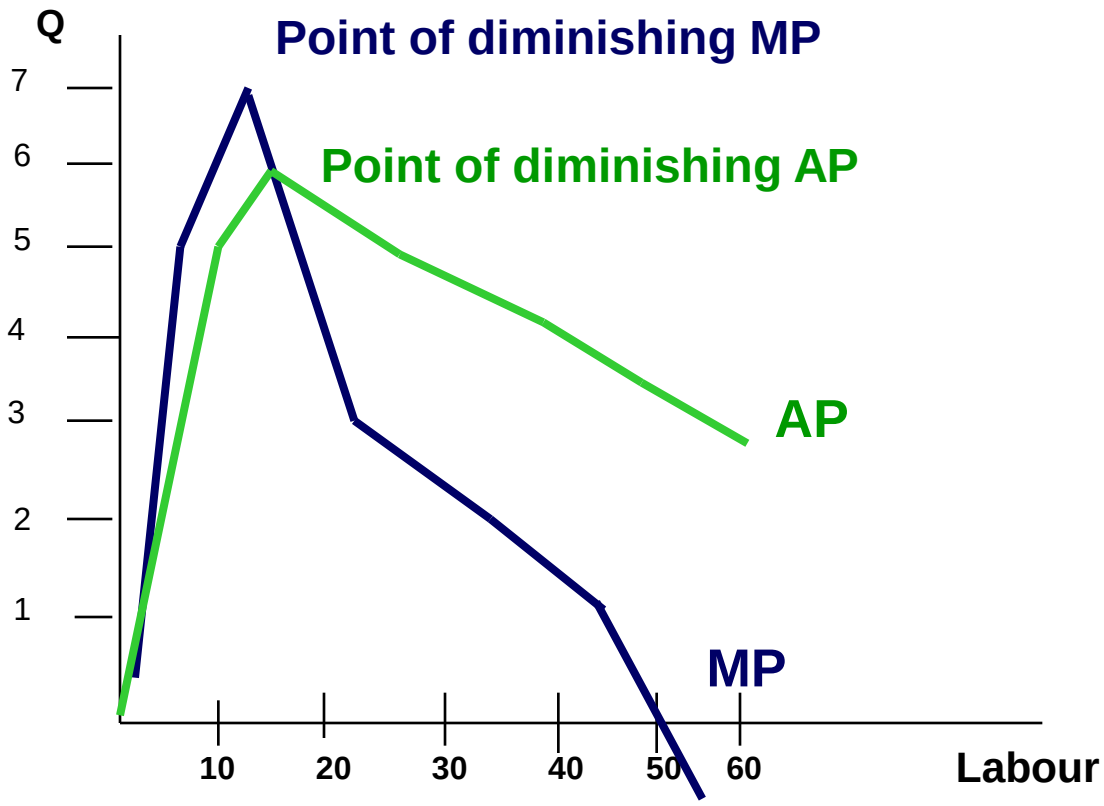
- Let's graph MP and AP:



When graphing MP, we are going from one level of labour to another, so we plot the points in between the labour-axis values.



When we graph AP, the points correspond exactly to the labour-axis values.

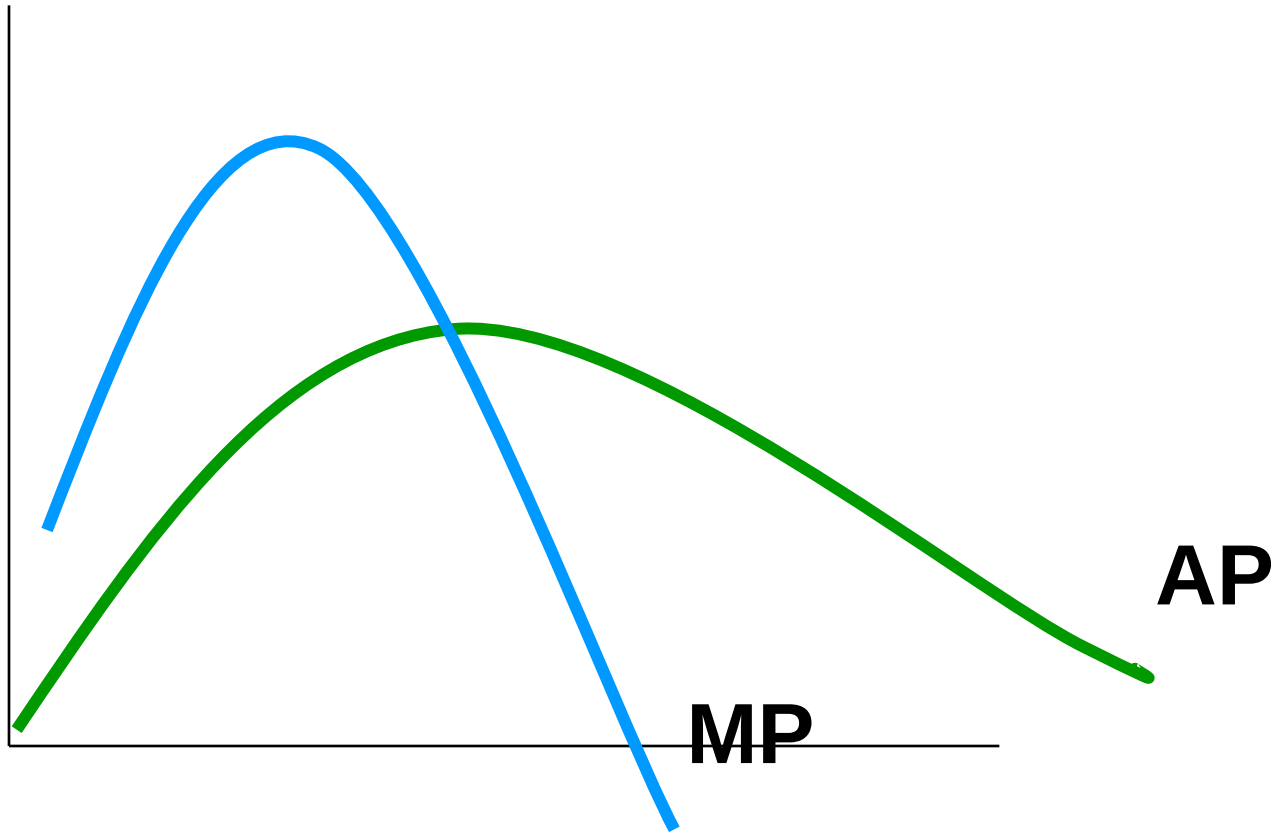

Q
Point of diminishing MP
Point of diminishing AP
AP
MP
7
6
5
4
3
2
1
10
20
30
40
50
60
Labour

Things to note:

- TP is maximized when L = 50
- This means that MP = 0 when L = 50

- AP intersects MP at max AP

- Most MP and AP curves are nice and smooth:



- Whenever MP > AP, AP must be ↑
- Whenever MP < AP, AP must be ↓

- Also note, Jerry wouldn't hire after the 50th worker because they lower his output.

Costs of Production

- Of course, Jerry is concerned about his costs of production.

- Costs of production may be divided into fixed costs and variable costs.

Fixed costs are those costs that do not vary with the quantity of output produced.

- Examples: rent, loan payments, salaried administrative staff

Variable costs are those costs that do vary with the quantity of output produced.

- Examples: labour costs, raw material costs

Costs also depend on the time horizon.

- We define:
- Short Run, SR: the period of time in which at least one input into production is fixed.
- Long Run, LR: the period of time in which all inputs into production can vary.

- Example: in the SR, factory size is fixed, but in the LR, you can build any size factory you choose.
- Note that the SR depends on the industry and the technology used, among other things.

Total Cost = Total Fixed Cost + Total Variable Cost

TC = TFC + TVC

- If there are fixed costs, the time period must be the SR.
- We'll examine the SR first.

Average Costs

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

ATC = TC / Q is average total cost

AFC = TFC / Q is average fixed cost

AVC = TVC / Q is average variable cost

ATC = AFC + AVC

- Suppose Jerry's fixed costs are $200 per week.

- His only variable cost is his labour cost.
- He pays each worker $500 per week.

L	Q	MP	TFC	TVC	TC
0	0		$200	$0	$200
10	50	5	200	5000	5200
20	120	7	200	10000	10200
30	150	3	200	15000	15200
40	170	2	200	20000	20200
50	180	1	200	25000	25200

Marginal Cost

- Jerry now wants to know how much extra it costs to increase production by assembling one more TV.
- We define:

Marginal Cost, MC as the increase in total cost that arises from an extra unit of production.

$$MC = \frac{\text{change in total cost}}{\text{change in total output}} = \frac{\triangle TC}{\triangle Q}$$

- MC is the slope of the total cost function.
- It measures the rate of change in total costs as total product changes.

- Let's calculate Jerry's MC:

L	Q	MP	TFC	TVC	TC	MC
0	0		$200	$0	$200	
10	50	5	200	5000	5200	$100
20	120	7	200	10000	10200	71
30	150	3	200	15000	15200	167
40	170	2	200	20000	20200	250
50	180	1	200	25000	25200	500

Notice that MC ↑ as MP ↓

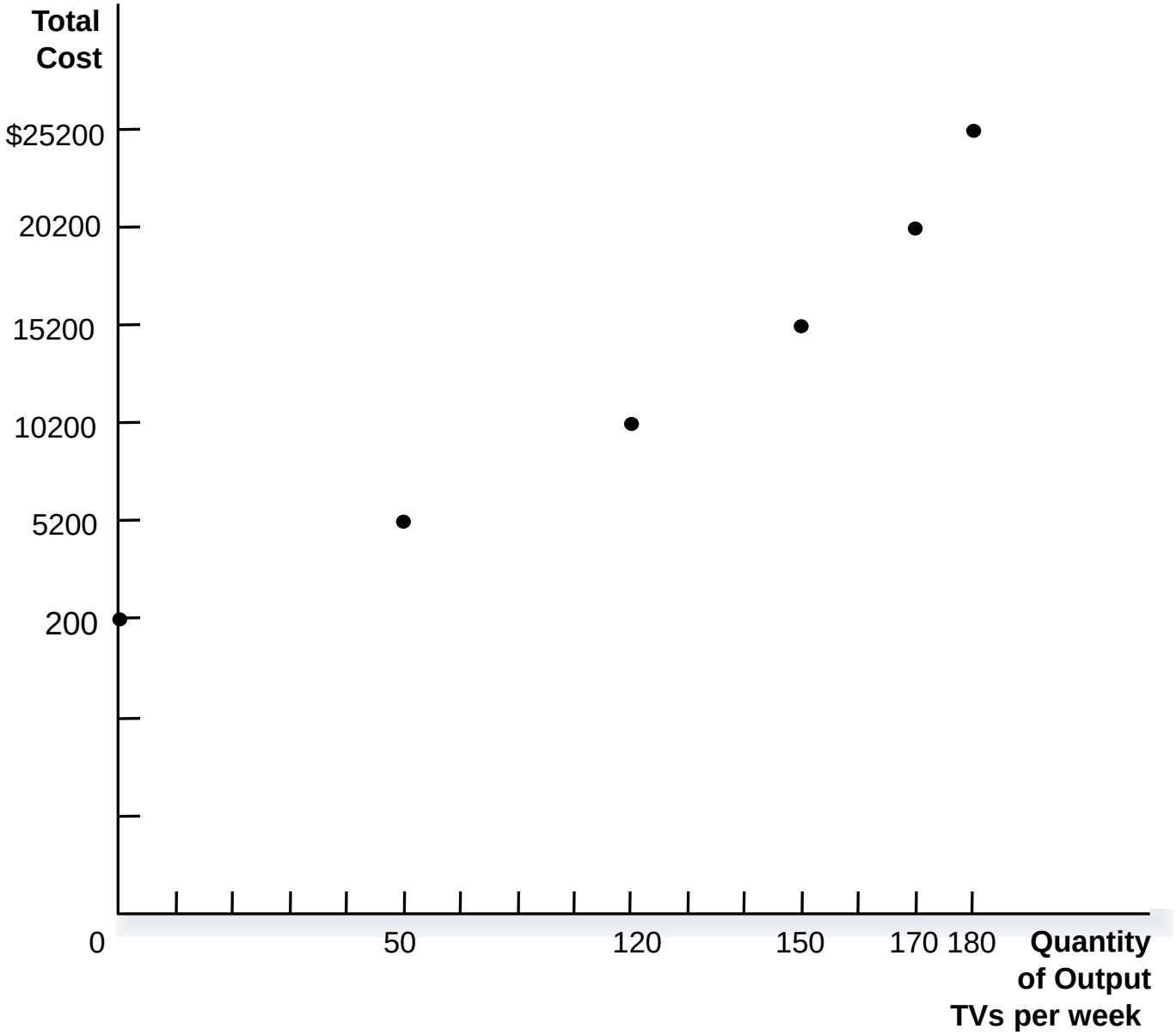
- Where MP is at a maximum, MC is at a minimum.
- MC is pretty much the inverse of MP.
- Think of it as the more productive workers are, the less their output contributes to total costs.

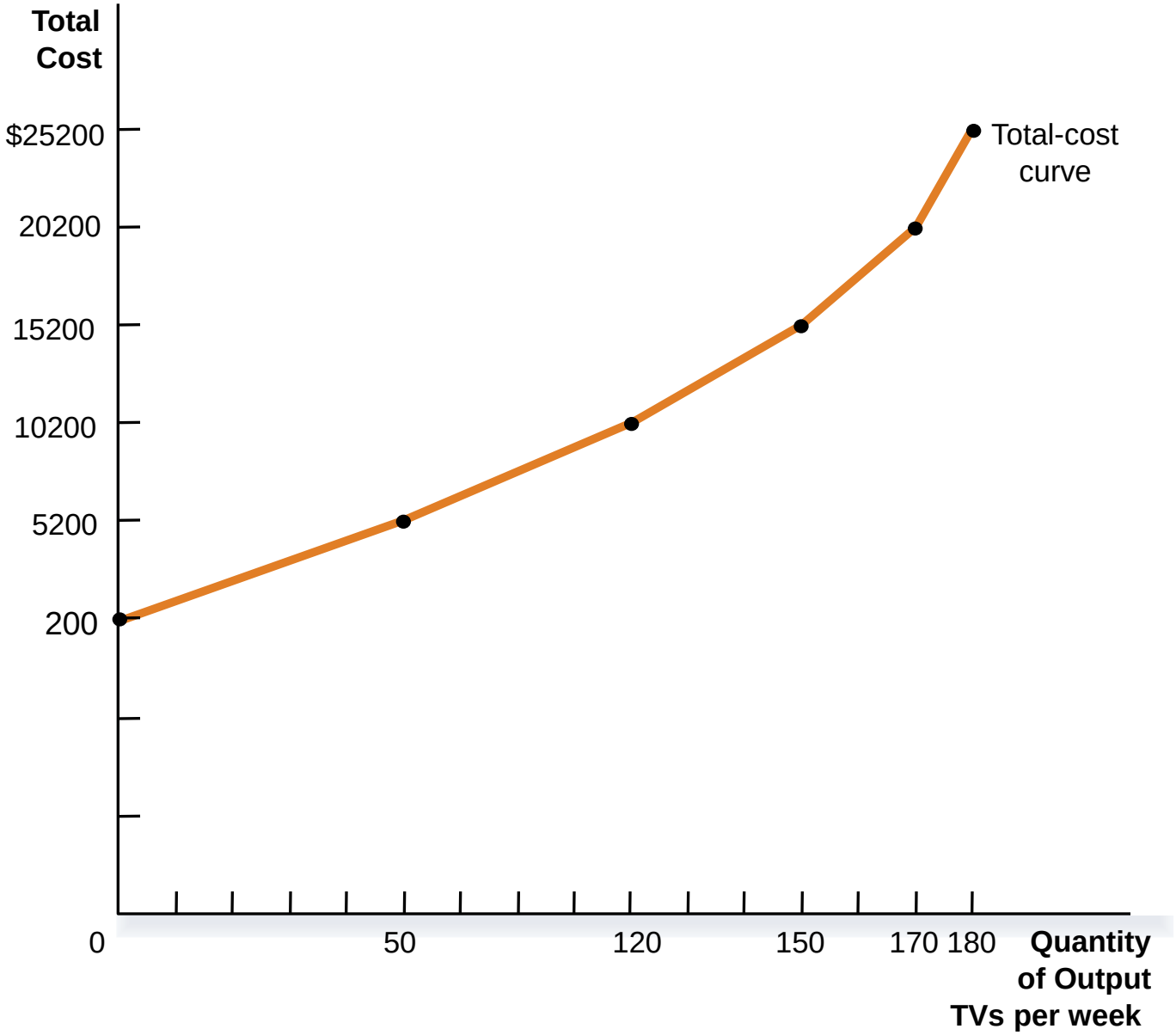
- Now, let's calculate Jerry's average costs:

Q	TFC	TVC	TC	MC	AFC	AVC	ATC
0	$200	$0	$200				
50	200	5000	5200	$100	$4	$100	$104
120	200	10000	10200	71	1.7	83	85
150	200	15000	15200	167	1.3	100	101
170	200	20000	20200	250	1.2	118	119
180	200	25000	25200	500	1.1	139	140

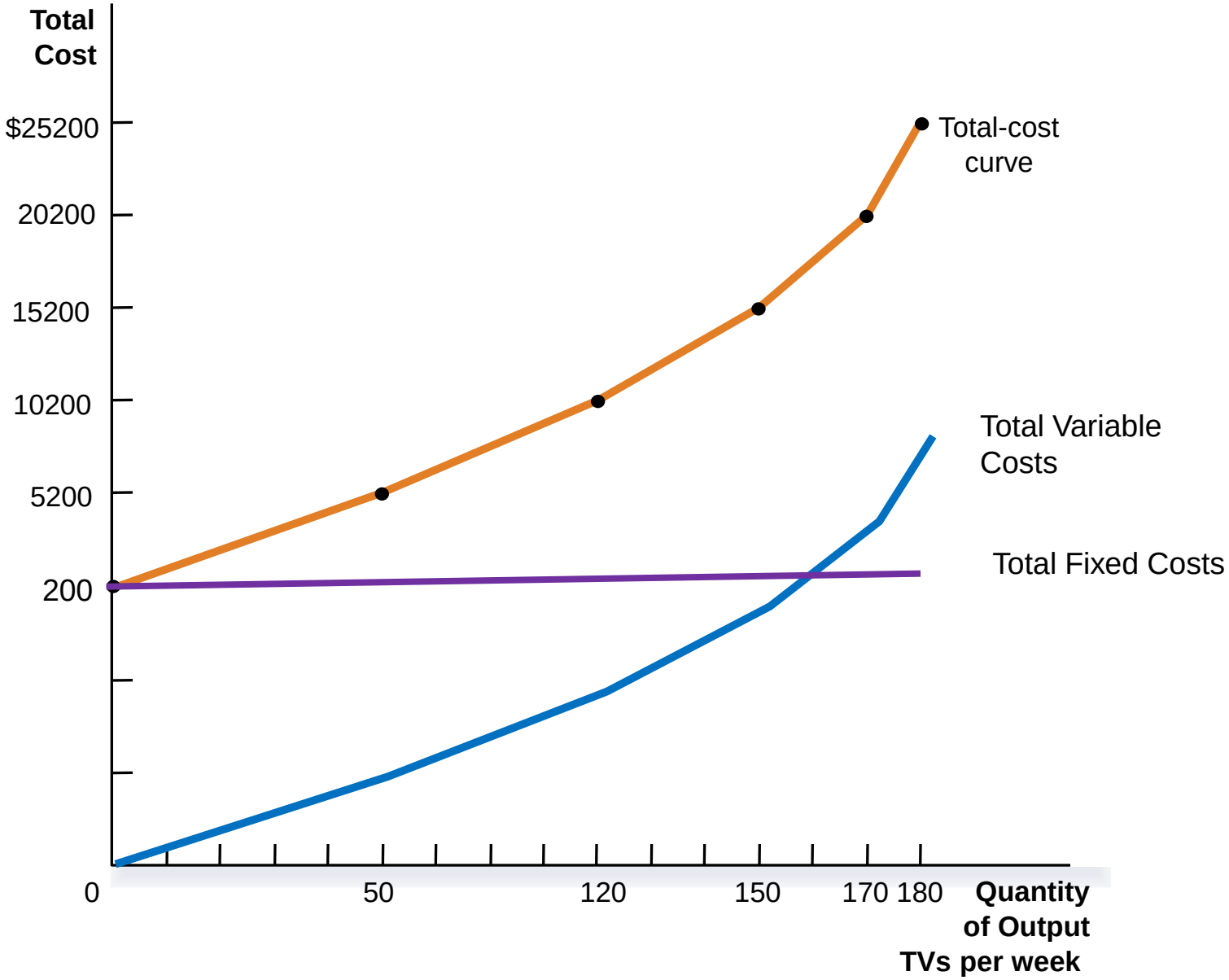
* I rounded all the average costs.

rry's TV Total Cost Curve



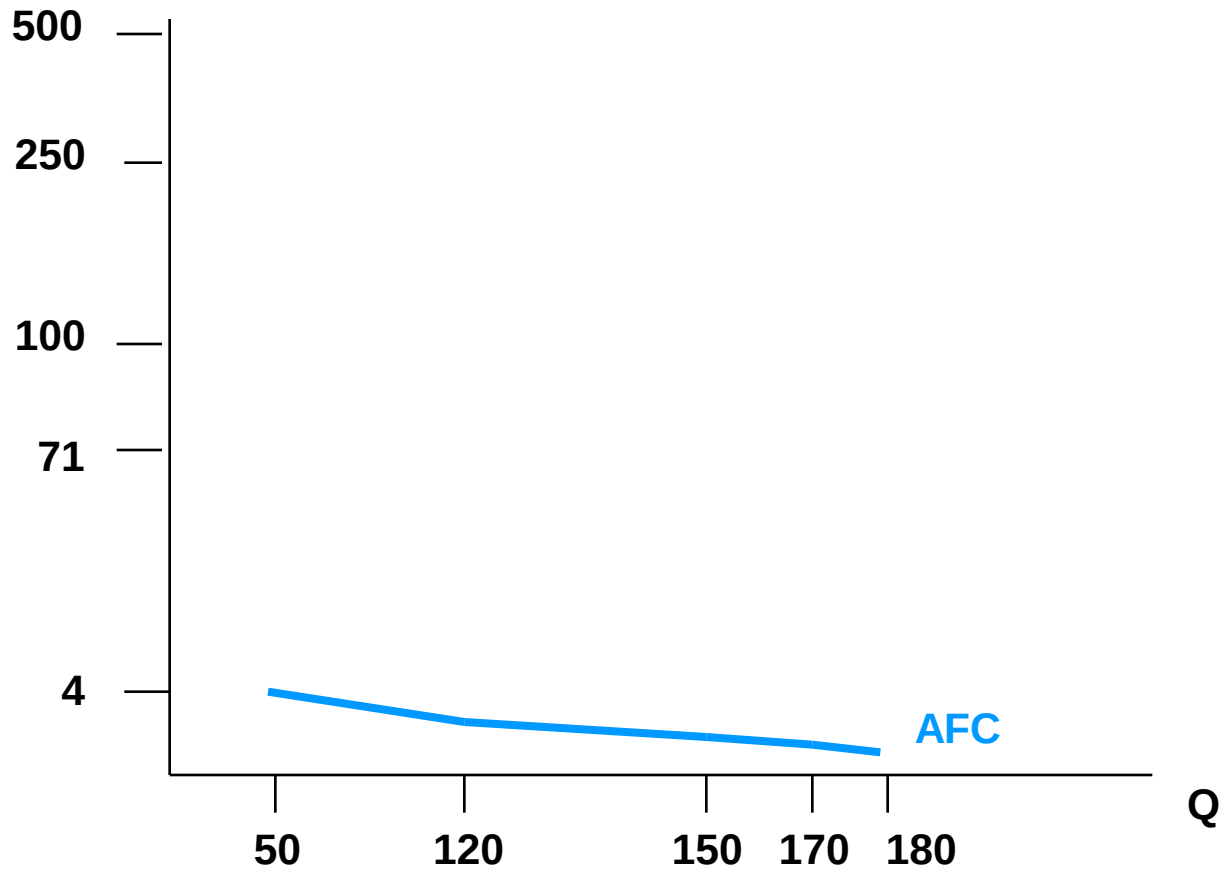

Total Cost
$25200
20200
15200
10200
5200
200
0
50
120
150
170
180
Quantity of Output TVs per week
Total-cost curve

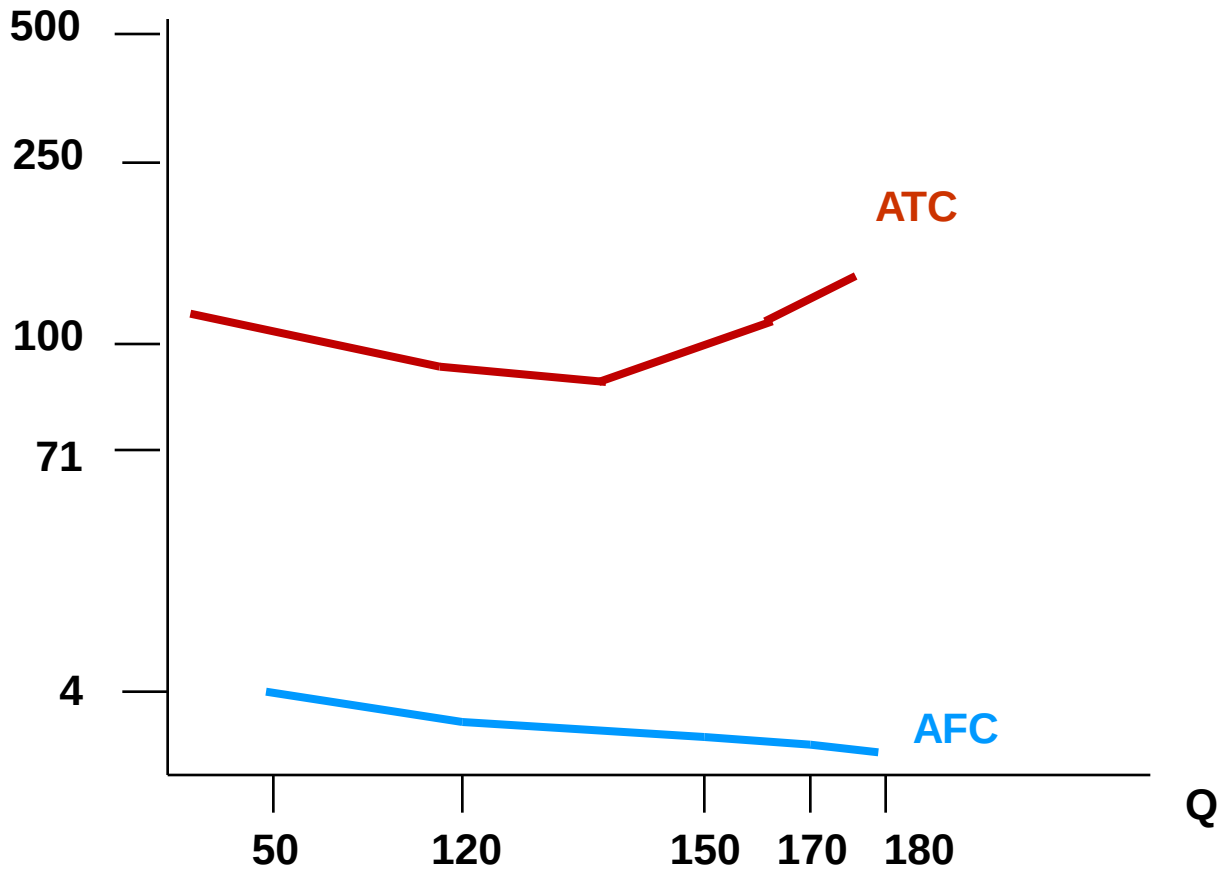
- Recalling that TC = TVC + TFC, let's add these costs to our TC diagram.
- The TC curve is simply the TVC curve shifted up by the amount of fixed costs.

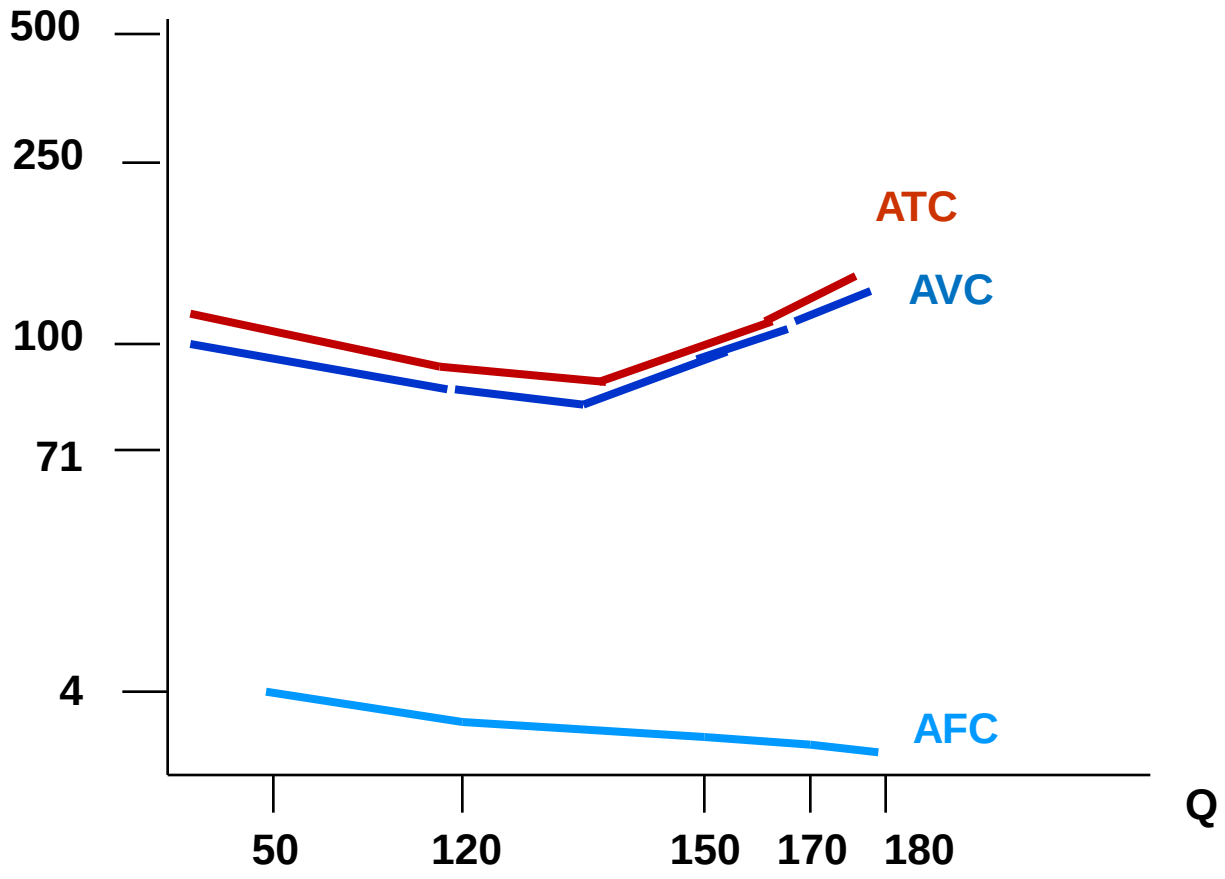

Total Cost
$25200
20200
15200
10200
5200
200
0
50
120
150
170
180
Quantity of Output TVs per week
Total-cost curve
Total Variable Costs
Total Fixed Costs

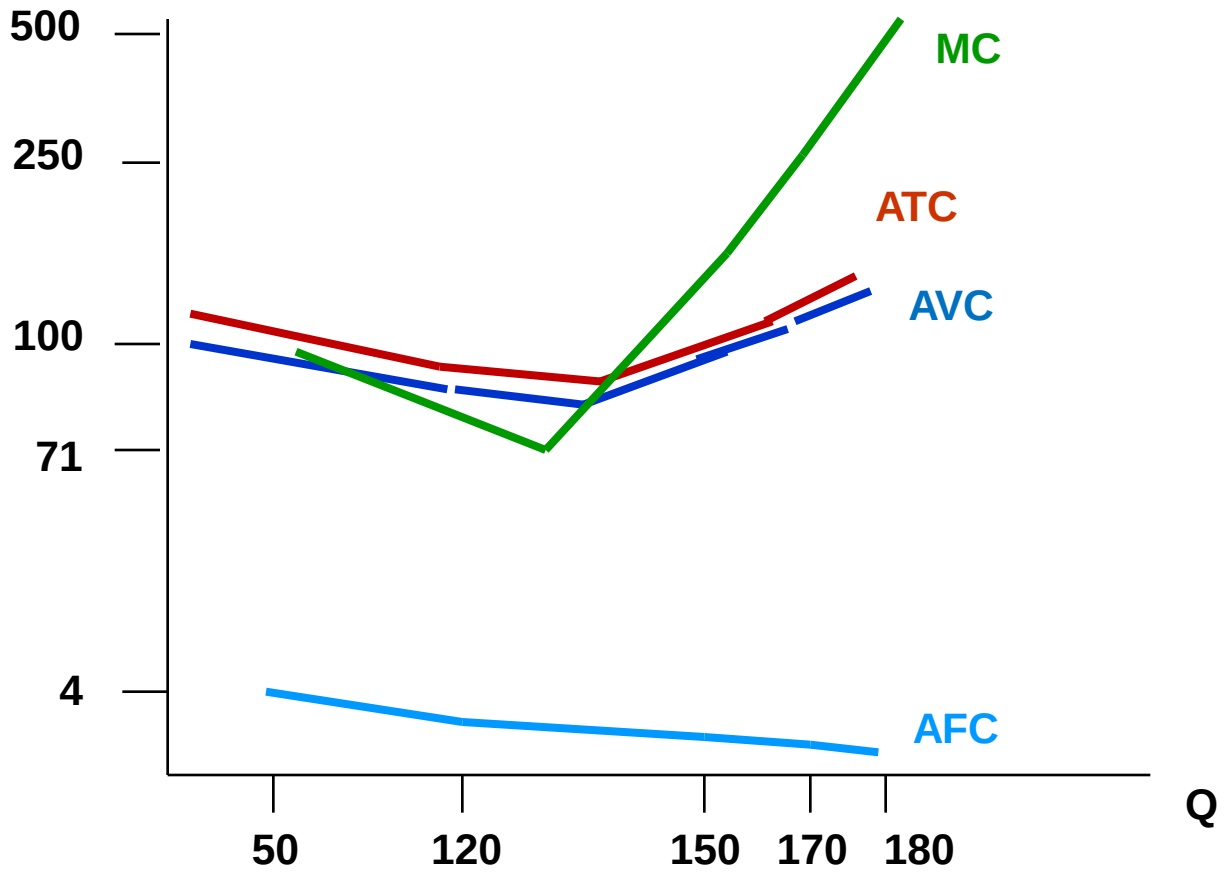
- The TC curve gets increasingly steeper.
- Costs start to increase faster due to diminishing MP.
- Let's now graph Jerry's average and marginal costs:

Jerry's SR Cost Structure

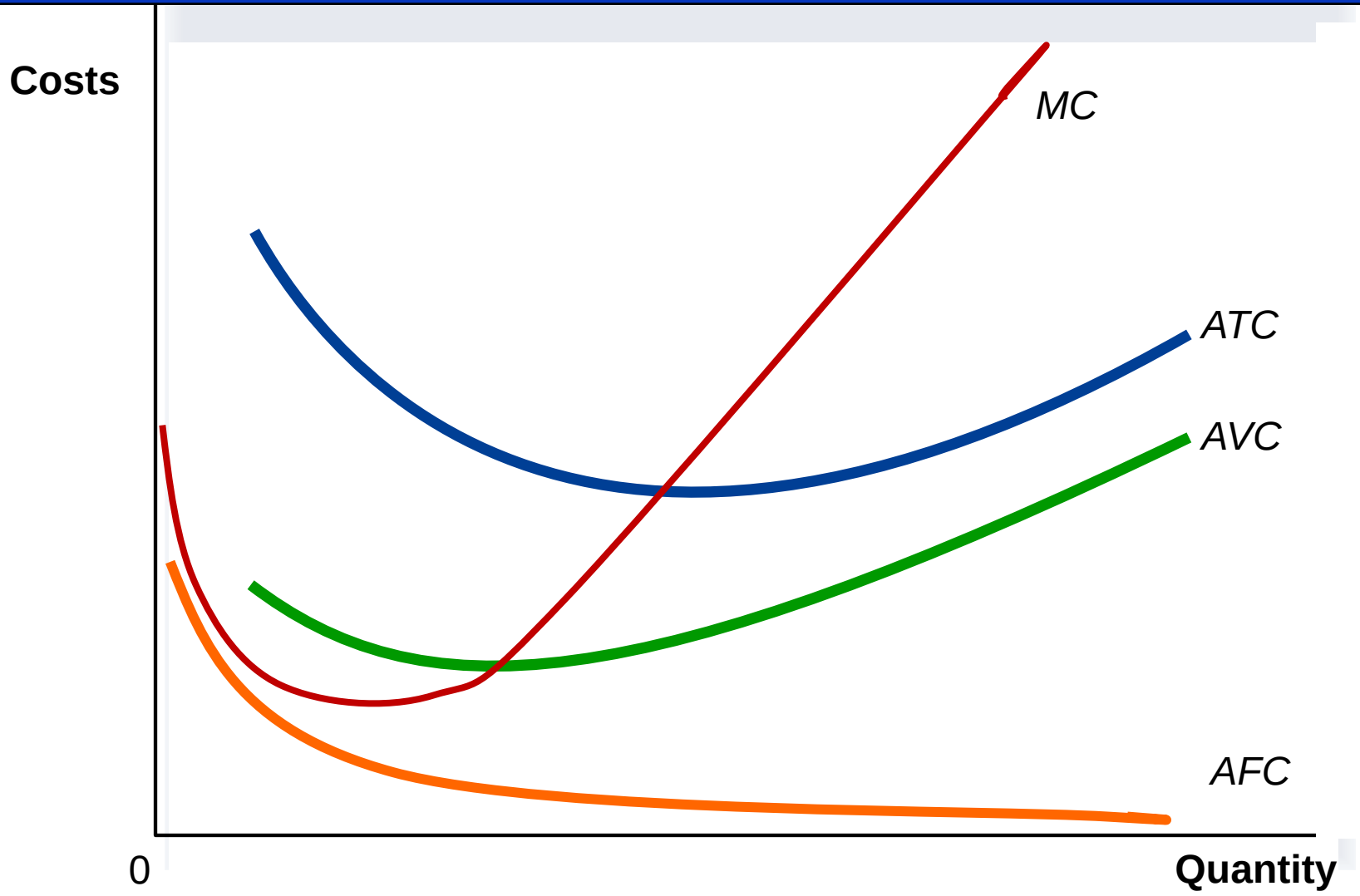



500
250
100
71
4
ATC
AFC
50
120
150
170
180
Q


500
250
100
71
4
ATC
AVC
AFC
50
120
150
170
180
Q


500
250
100
71
4
MC
ATC
AVC
AFC
Q
50
120
150
170
180

Typical SR Cost Curves That We Traditionally Sketch



Note that:

- MC intersects AVC at min AVC.
- MC intersects ATC at min ATC.

- Whenever MC < AVC or ATC, AVC and ATC must be falling.
- Whenever MC > AVC or ATC, AVC and ATC must be rising.

- Min ATC is the point of efficient scale.
- We say the firm is operating at capacity (or efficient capacity) – just the right amount of output.

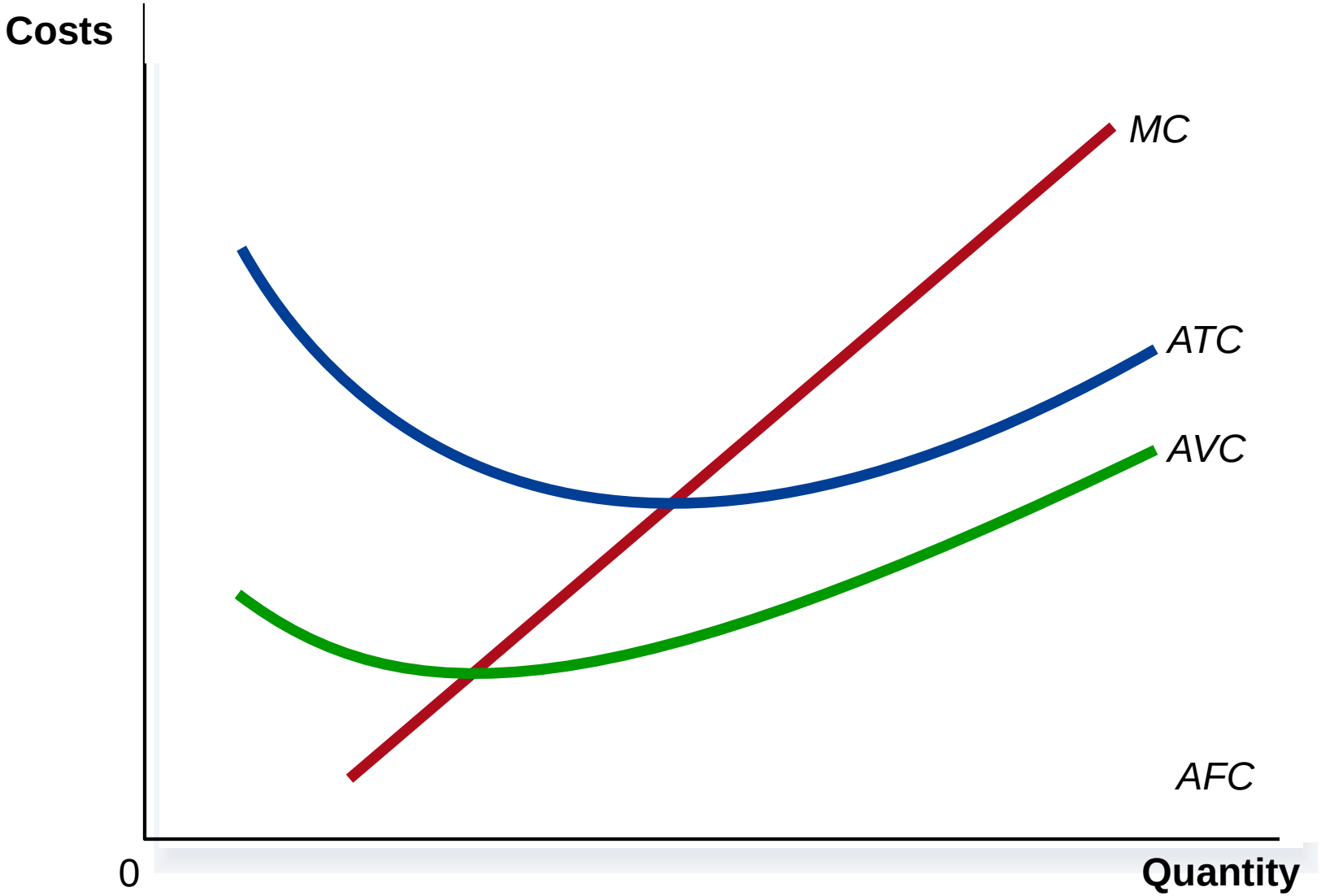
- Any Q greater or less than the Q at min ATC has a higher ATC.
- If we're producing Q such that we're at efficient scale, we are minimizing ATC.

- The ATC curve is U-shaped because:
- At very low levels of output average total cost is high because fixed cost is spread over only a few units.
- Average total cost declines as output increases.
- Average total cost starts rising because average variable cost rises substantially.

- MC eventually rises with output.
- The distance between ATC and AVC on the diagram is AFC.
- The MC curve is the “inverse” of the MP curve and ATC is the “inverse” of AP.

- We often omit drawing the AFC curve because as we shall soon see, AFC doesn't really play a role when firms decide how much to produce in the SR.
- Moreover, the MC curves in the diagrams in the text are depicted as linear (no doubt for convenience).
- Generally, MC decreases initially and then rises as diminishing MP sets in, as in our example of Jerry's TVs.

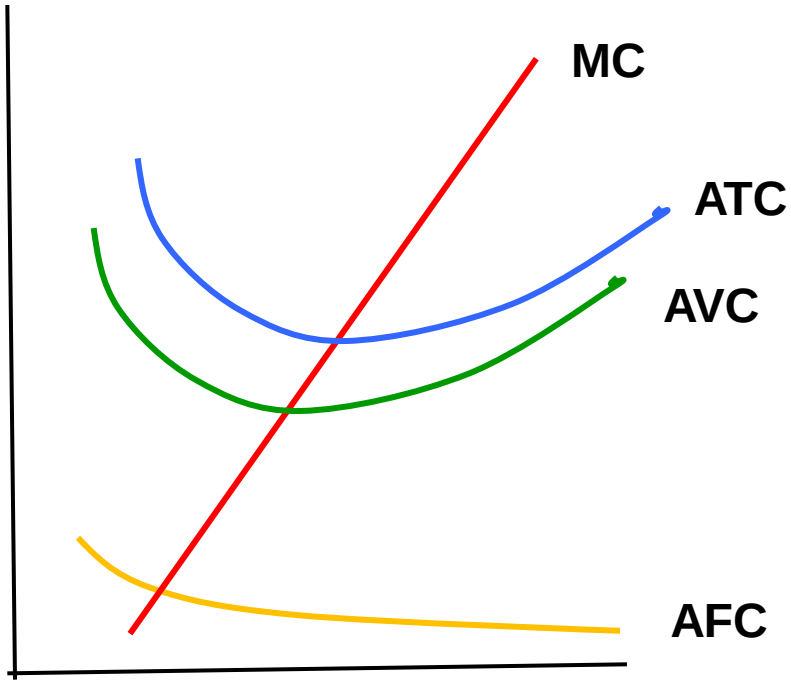
Typical SR Cost Curves That You'll See



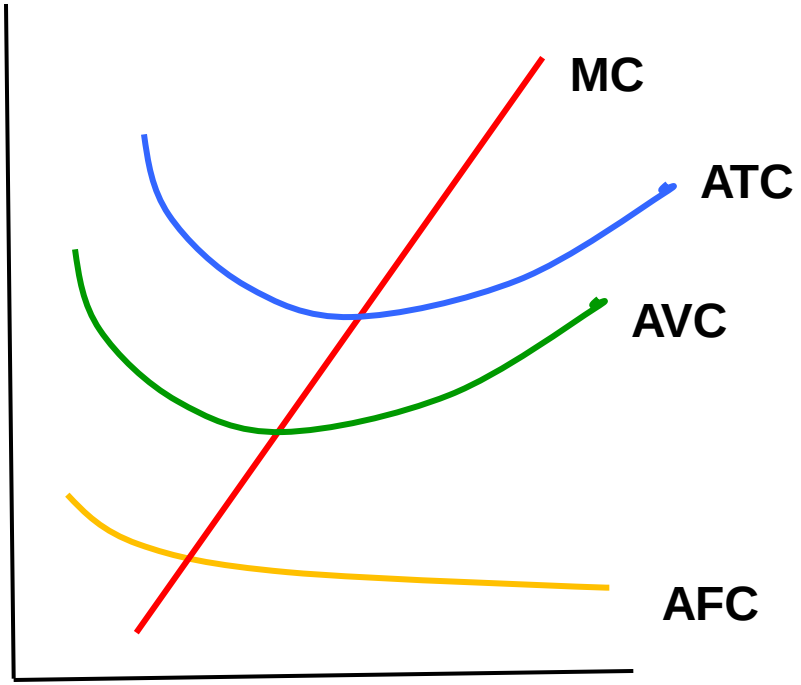
Changes in Short Run Costs

- When costs change, the firm's SR cost structure will change.
- For example, say Jerry hires an office manager whose salary increases his fixed costs.
- This will also increase his average fixed costs and his average total costs.
- These curves will shift up on our SR cost diagram.

The AFC and ATC curves shift up when AFC increases.



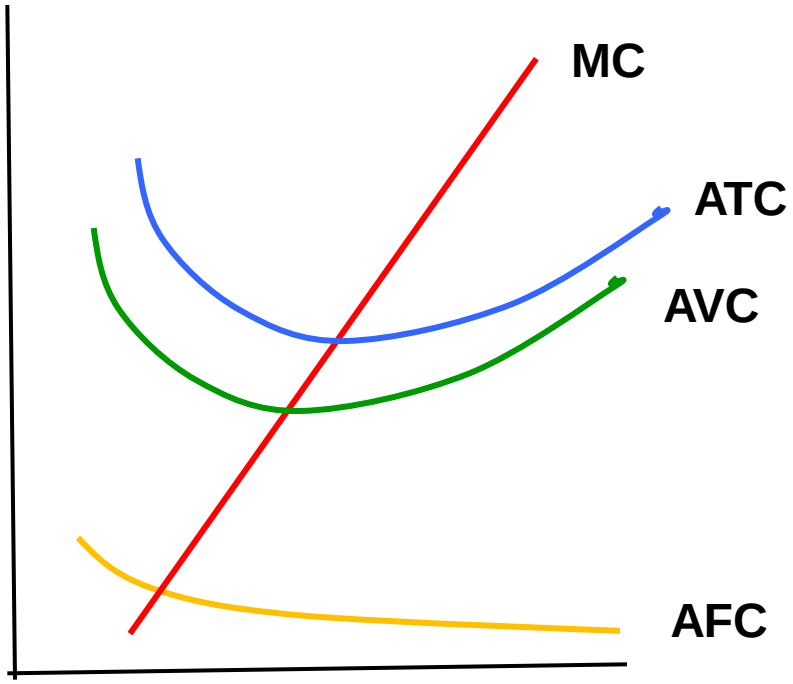
Original Costs



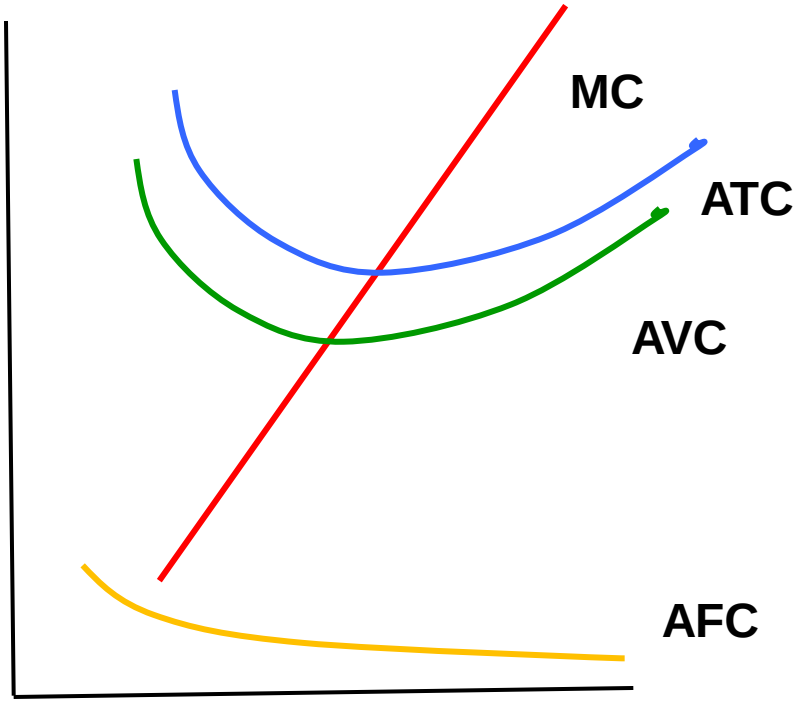
After AFC Increases

- Suppose that Jerry's labour costs increase.
- This will increase variable, marginal and total costs.
- The AVC, MC and ATC curves will shift up.

The AVC, MC and ATC curves shift up when variable costs increase.



Original Costs



After Variable Costs Increase

- If costs decreased, the affected curves would shift down.

Costs in the Long Run and Short Run

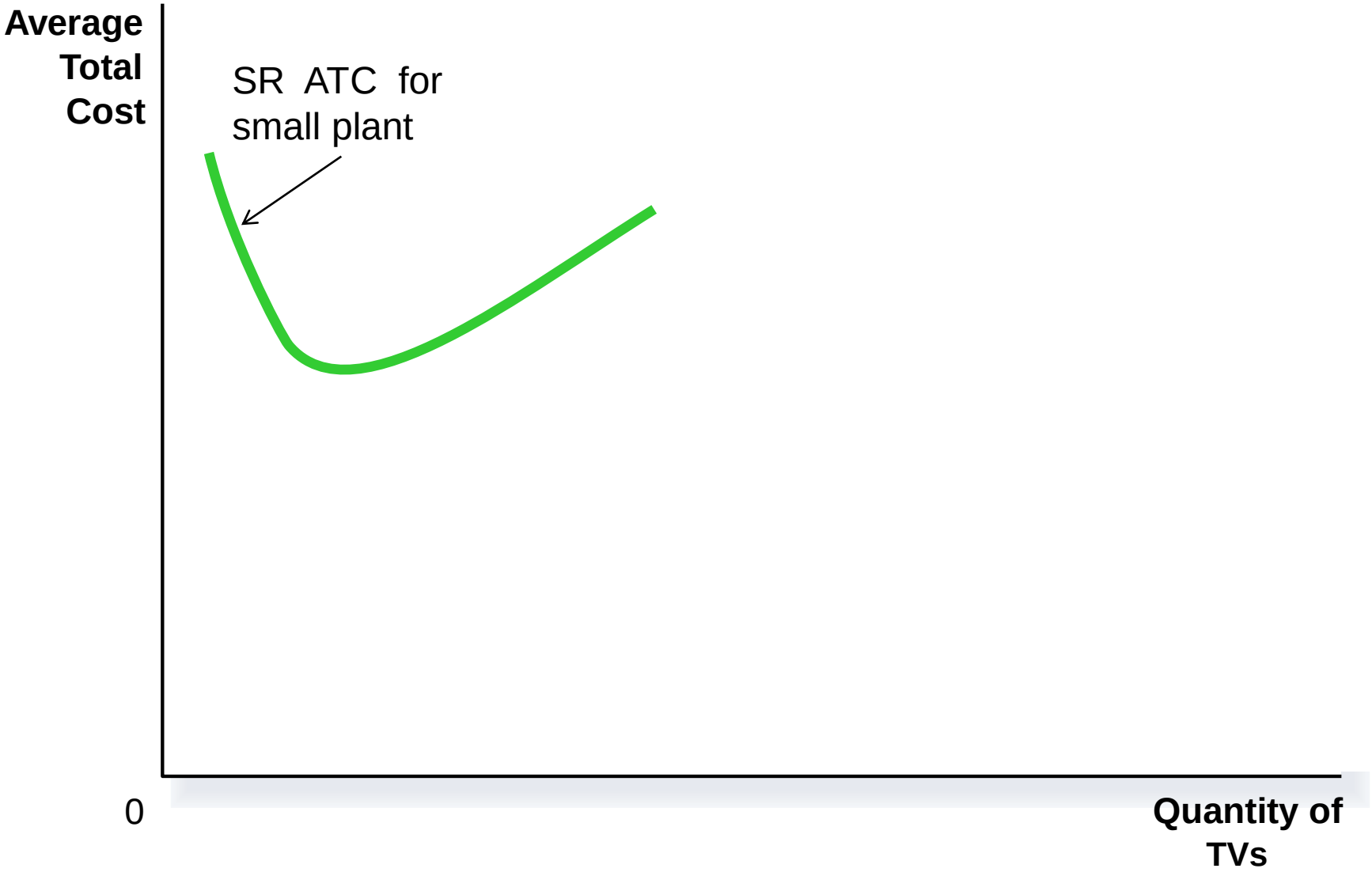
- Because many costs are fixed in the short run but variable in the long run, a firm's long-run cost curves differ from its short-run cost curves.

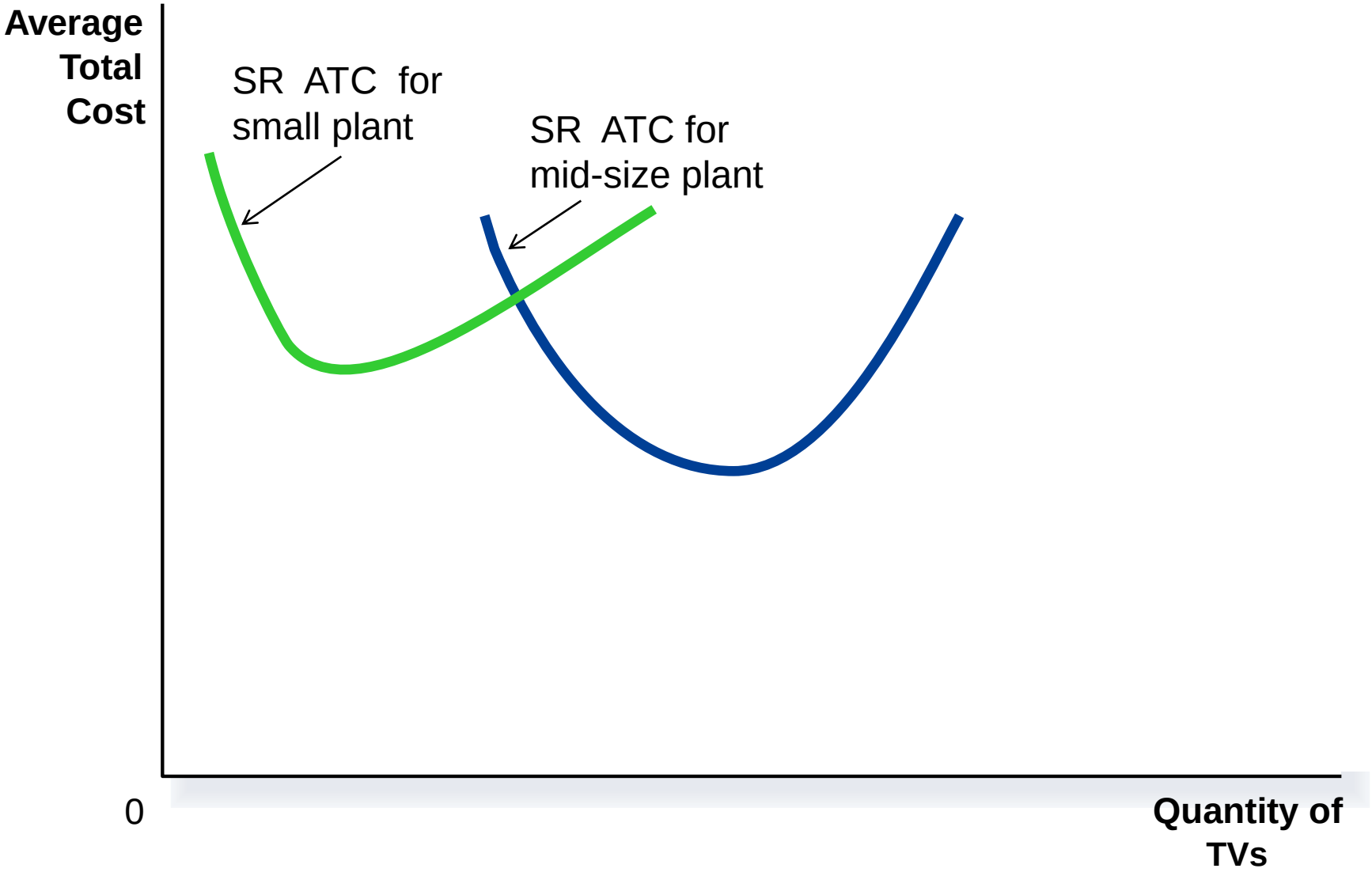
- Jerry's factory size is fixed in the SR (it's a fixed input)
- In the SR, the cost of the factory is fixed.

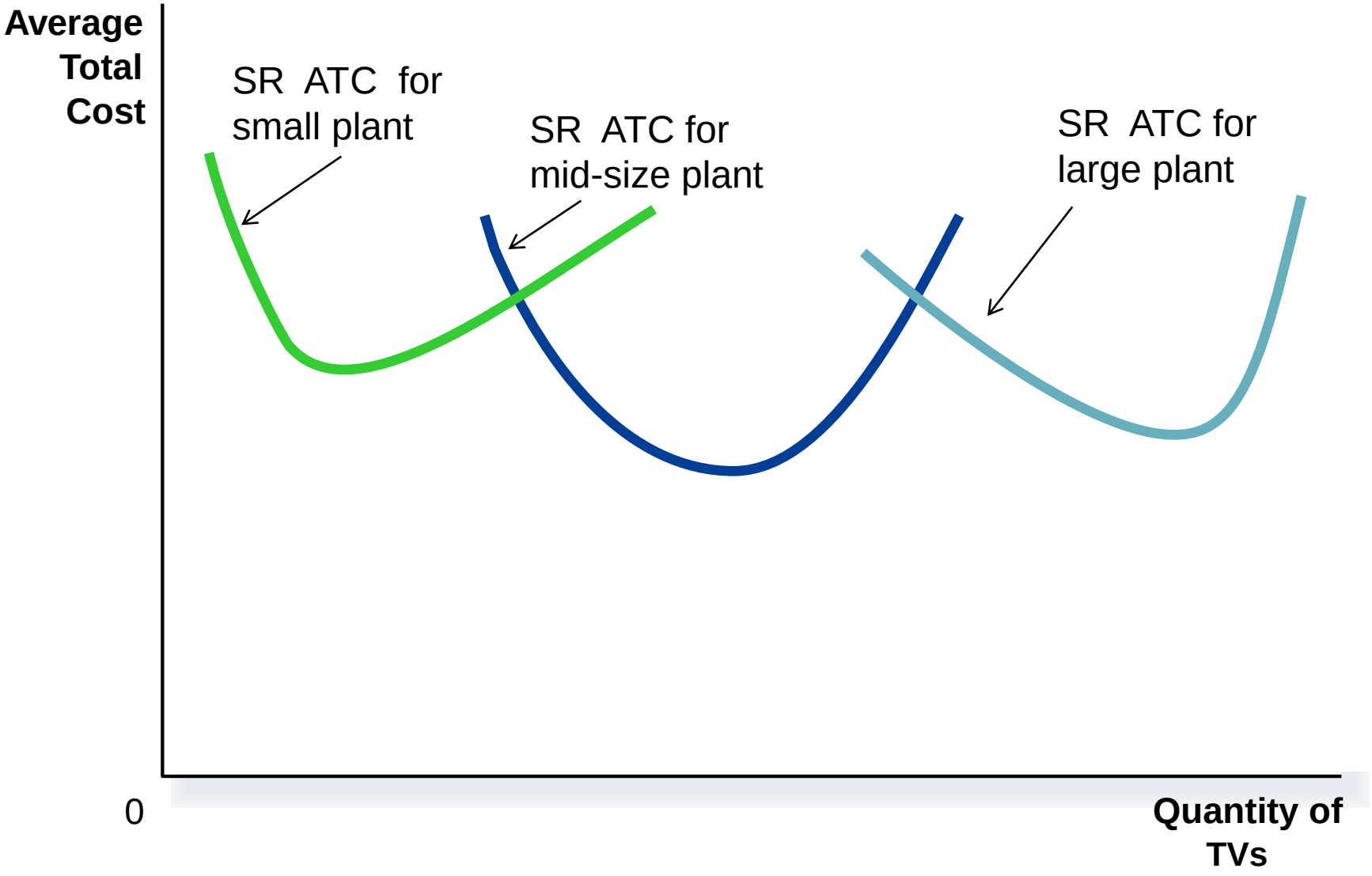
- In the LR, Jerry can build a bigger factory, buy more machines, etc.
- In the LR, his factory cost is a variable cost.

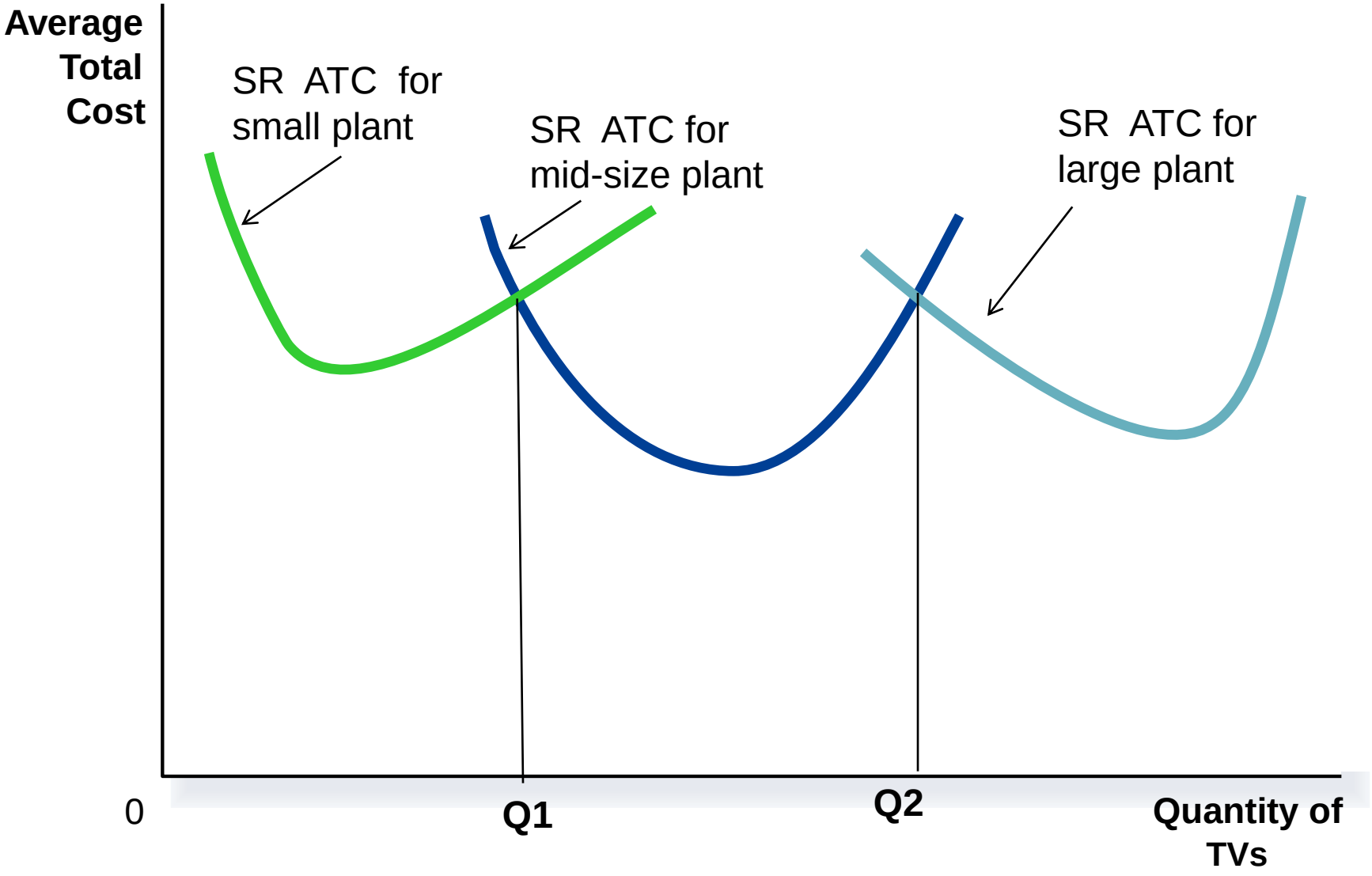
- Consider 3 different sizes of factories Jerry could build in the LR:
- A small factory
- A medium-sized factory
- A large factory

There is a different set of SR cost curves for each size of factory (once you build the plant, you incur new fixed costs, so for every LR there's an associated SR).


Average Total Cost
SR ATC for small plant
0
Quantity of TVs

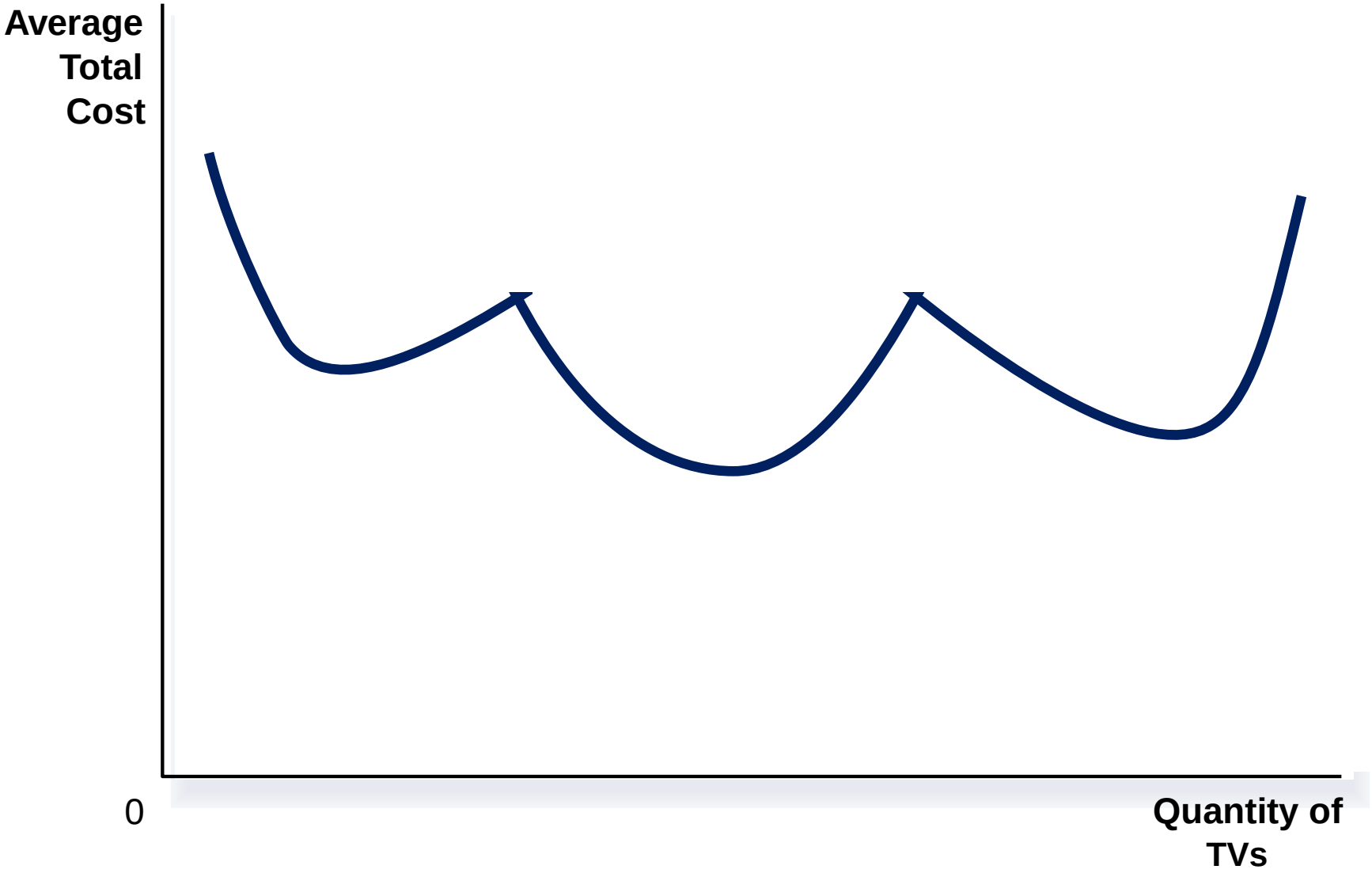

Average Total Cost
SR ATC for small plant
SR ATC for mid-size plant
0
Quantity of TVs


Average Total Cost
SR ATC for small plant
SR ATC for mid-size plant
SR ATC for large plant
0
Quantity of TVs


Average Total Cost
SR ATC for small plant
SR ATC for mid-size plant
SR ATC for large plant
0
Q1
Q2
Quantity of TVs

- For Q produced between 0 and Q1, the small factory has the lowest cost.
- For Q produced between Q1 and Q2, the mid-sized factory has the lowest cost.
- For any Q produced above Q2, the large factory has the lowest cost.
- Jerry's LR Average Cost curve, LRAC, is the envelope of all the lowest costs for the different sizes of factories.

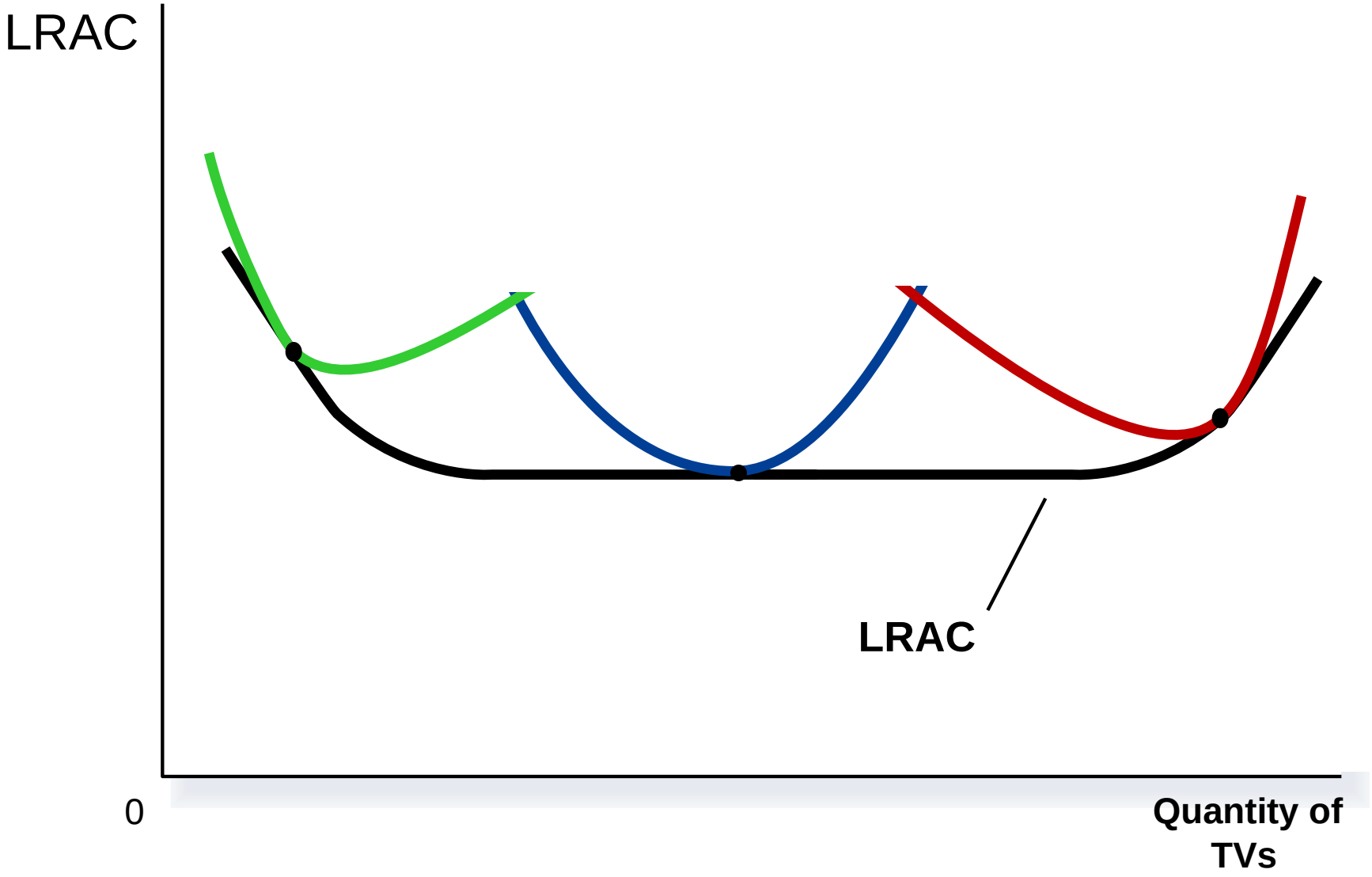
Jerry's LRAC Curve



- If Jerry considered an infinite number of factory sizes, he'd face an infinite number of SR cost curves.

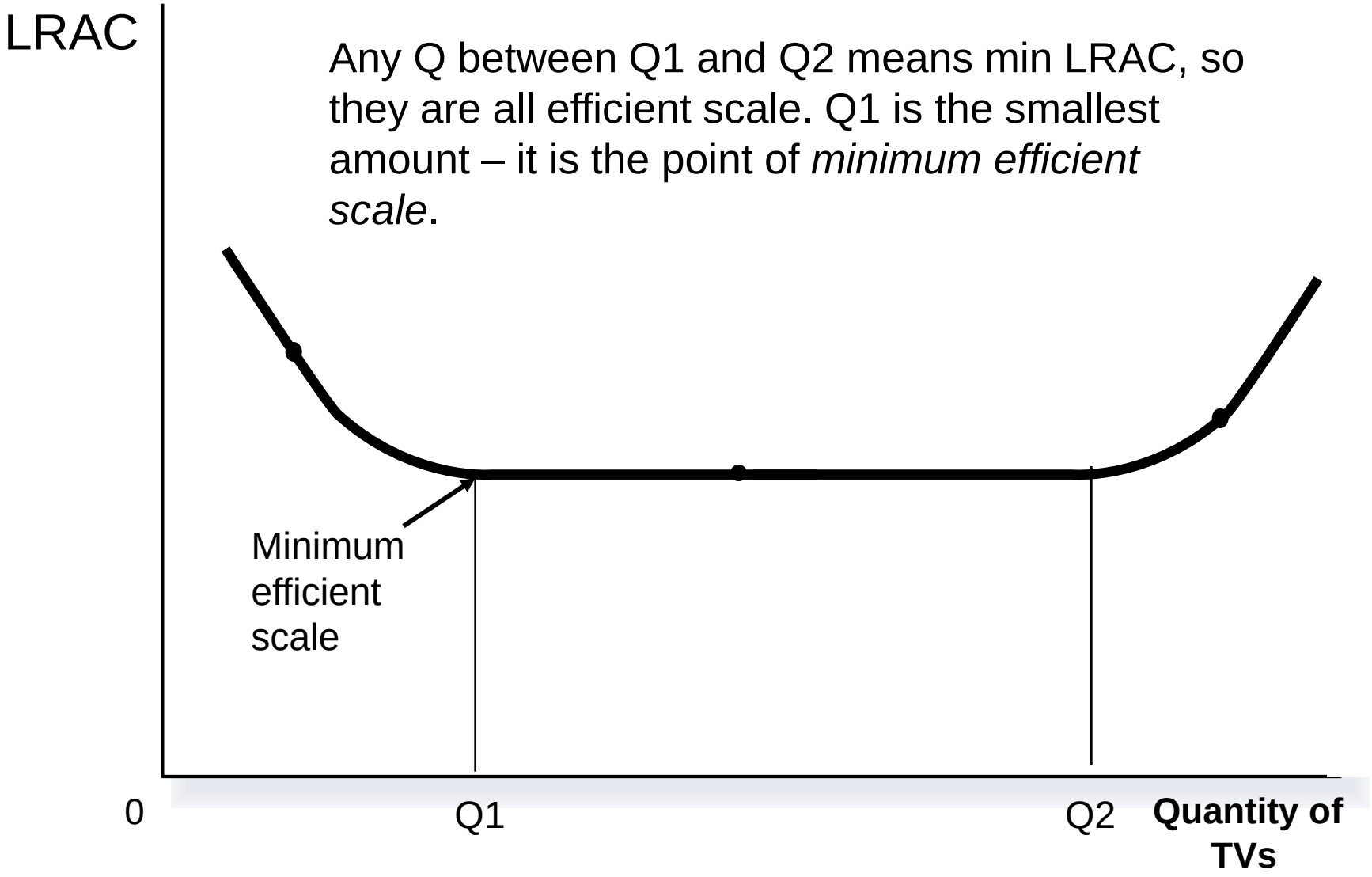
- His LRAC would be a nice, smooth curve.
- It's still u-shaped, but it tends to be flatter on the bottom.

Long Run Average Cost



- Just like in the SR, we can talk about producing at efficient scale.
- The level of output Q which minimizes LRAC is the point of efficient scale.

Efficient Scale



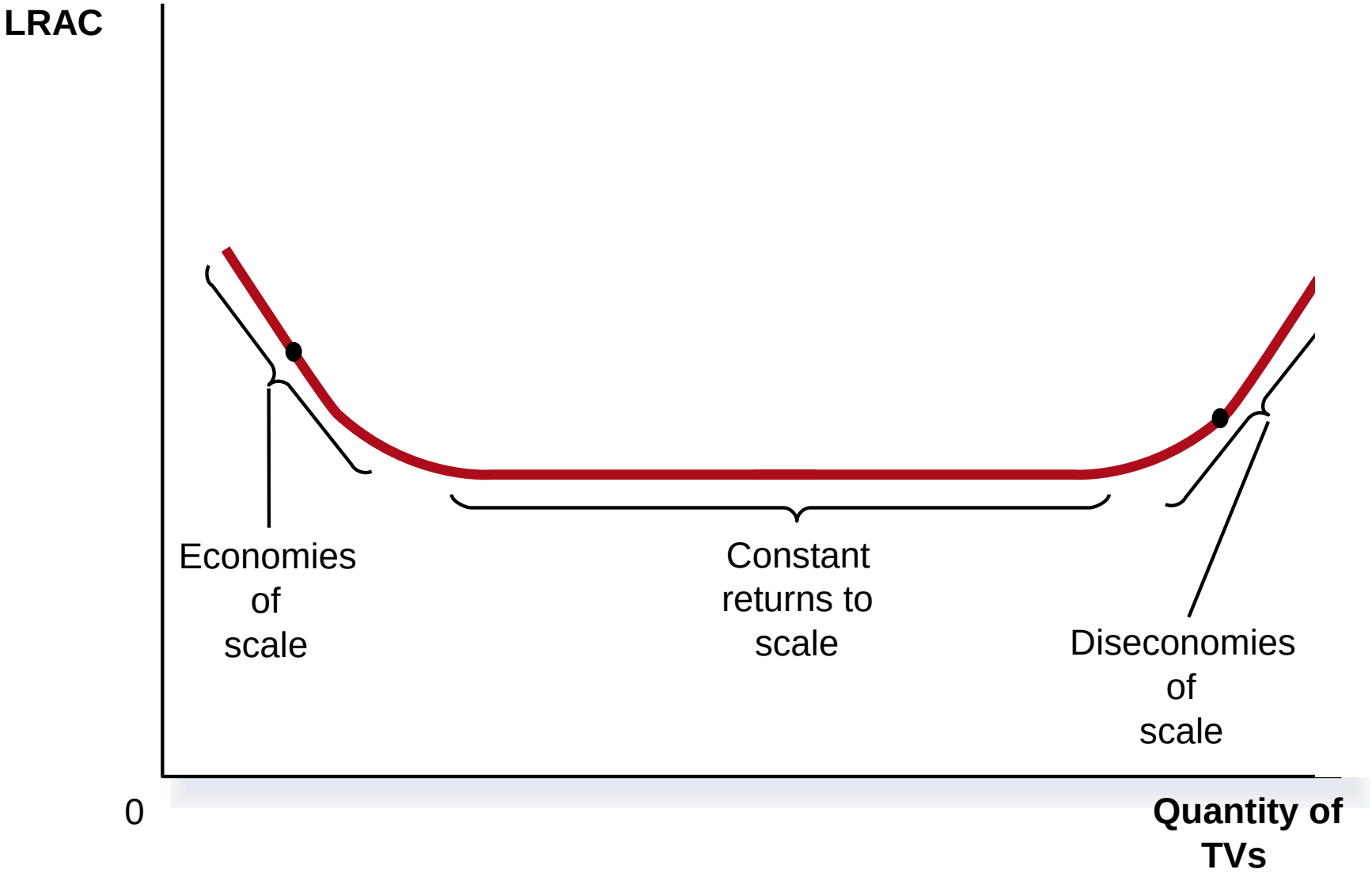
Scale Economies in the LR

- Different levels of output place firms on different points on their LRAC curve.
- Increasing production can have different impacts on cost.

- We define:

- Economies of scale, EOS: long-run average total cost falls as Q ↑.
  - Also called increasing returns to scale (IRS) or scale economies
- Diseconomies of scale, DOS: long-run average total cost rises as Q ↑.
  - Also called decreasing returns to scale (DRS)
- Constant returns to scale, CRS: long-run average total cost stays the same as Q ↑.

EOS, CRS and DRS



- Economies of scale occur when increasing production allows greater specialization: workers are more efficient when focusing on a narrow task.
- This is more common when Q is low.

- Diseconomies of scale are due to coordination problems in large organizations.
- For example, management becomes stretched and can't control costs.
- This more common when Q is high.

- Another way to think about economies of scale:
- IRS: if you increase inputs by some factor X, you get more than an X increase in output.
- CRS: if you increase inputs by some factor X, you get exactly an X increase in output.
- DRS: if you increase inputs by some factor X, you get less than an X increase in output.

- If a firm is experiencing increasing returns to scale (economies of scale), it can lower its average costs by producing more output.
- If a firm is experiencing decreasing returns to scale (diseconomies of scale), it can lower its average costs by cutting back on production.

Summary of Production Costs

Term	Definition	Mathematical Description
Explicit costs	Costs that require an outlay of money by the firm	—
Implicit costs	Costs that do not require an outlay of money by the firm	—
Fixed costs	Costs that do not vary with the quantity of output produced	FC
Variable costs	Costs that do vary with the quantity of output produced	VC
Total cost	The market value of all the inputs that a firm uses in production	$TC = FC + VC$
Average fixed cost	Fixed costs divided by the quantity of output	$AFC = FC/Q$
Average variable cost	Variable costs divided by the quantity of output	$AVC = VC/Q$
Average total cost	Total cost divided by the quantity of output	$ATC = TC/Q$
Marginal cost	The increase in total cost that arises from an extra unit of production	$MC = \Delta TC/\Delta Q$