## Chapter 11

# Inputs and Costs

**This chapter is about *firms*' use of marginal analysis to make output decisions.**

## Vocabulary:

**Fixed inputs** = inputs whose quantity cannot change easily.

**Examples: Factory capacity or the amount of land a farmer has for growing crops**

**Variable inputs** = inputs whose quantity can be changed in the short run.

**Examples: The amount of fertilizer or seeds a farmer uses; or the number of workers a factory hires**

**Long run** = the time period over which all inputs can change.

**Example: the time it takes to buy more land or build another factory**

**Short run** = the time period over which at least one input is fixed.

**Example: in the short run a farmer can change the number of workers but not the size of land.**

# Production Functions

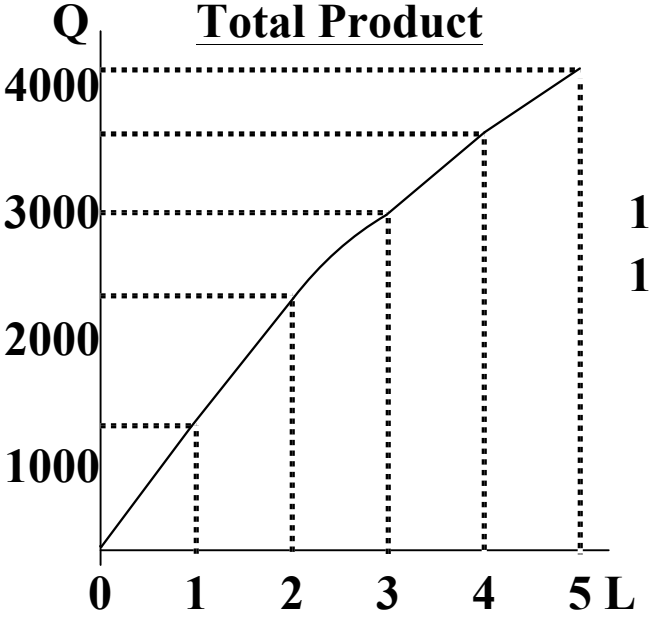
**The Total Product Curve shows the relationship between** total output and the quantity of the variable input, given a certain quantity of the fixed input.

**The marginal product of labour** = change in quantity of output which one extra worker, given a certain quantity of the fixed input.

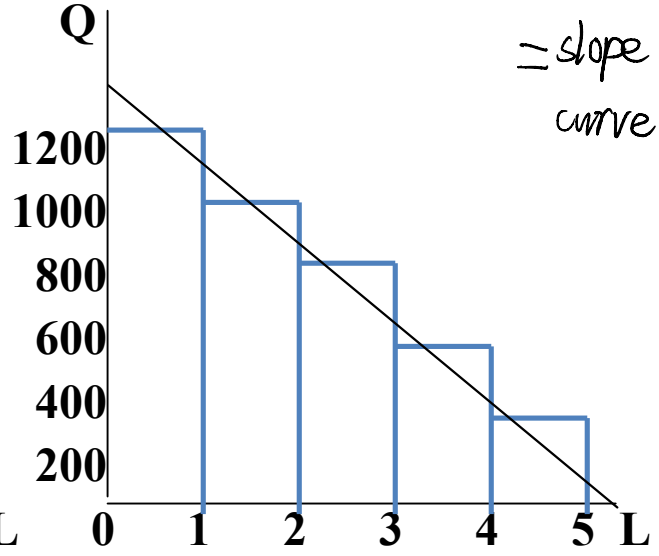
| # of Workers | Total Output | MPL |
|---|---|---|
| 0 | 0 | |
| | | 1200 |
| 1 | 1200 | |
| | | 1000 |
| 2 | 2200 | |
| | | 800 |
| 3 | 3000 | |
| | | 600 |
| 4 | 3600 | |
| | | 400 |
| 5 | 4000 | |

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

**Total Product**




**Marginal Product** $= \frac{\Delta Q}{\Delta L}$ = slope of TP curve



## Why is MPL so Important?

- **Recall that *rational people think at the margin.***
- **When a producer hires an extra worker,**
  - costs rise by the wage paid to the worker.
  - Outputs rises by the MPL.
- **Comparing the wage to the MPL helps firms decide whether or not it would be profitable to hire the extra worker.**


**There are <u>diminishing returns to an input</u> when**

the MP of the input falls, holding other input fixed.

- **In the above example there are *diminishing returns to labour* or *diminishing marginal product of labour*.**
- **The slope of the TP curve is MP, so a diminishing MP will result in a concave TP curve (decreasing slope).**

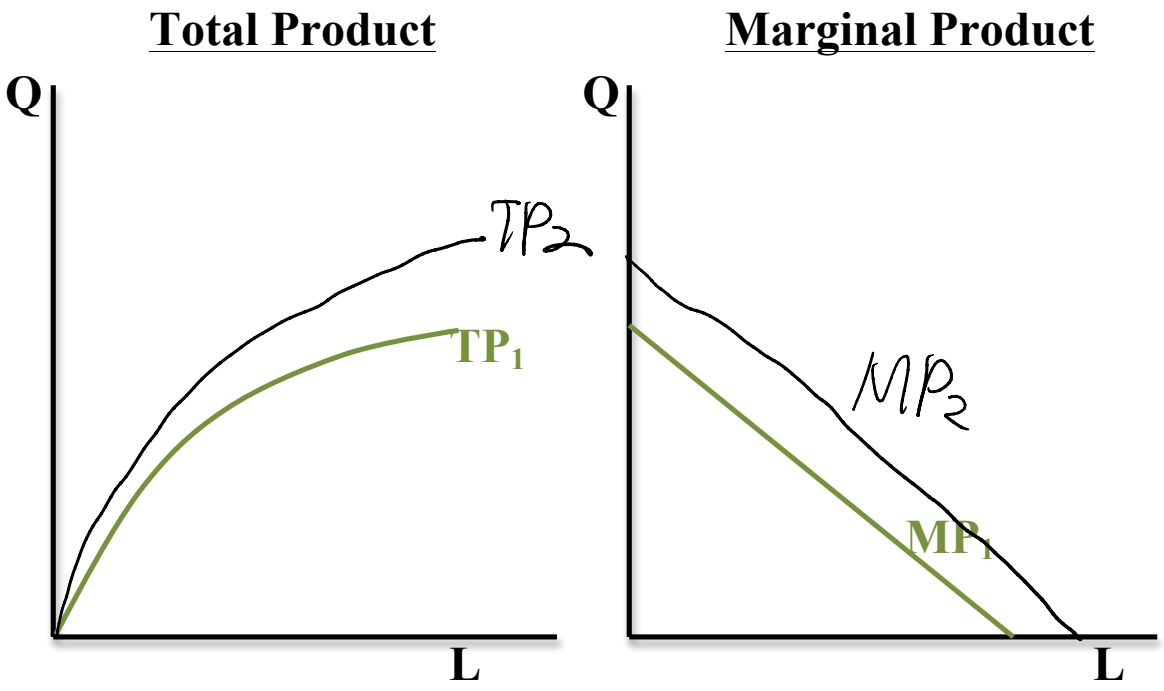
## Why MPL Diminishes

**The marginal product of an input declines as the quantity of the input increases, for a given amount of fixed input.**

**E.g. A farmer's output rises by a smaller and smaller amount with each additional worker. Why?**

- **If a farmer increases workers but not land,**

**An increase in the amount of the fixed input (e.g. land) will shift the TP and MP curves up:**




**Technology**

**Technology is also a fixed input because it takes time to improve.**

**An improvement in technology will have the same effect as more of a fixed input:** the TP and MP curves will shift up.

# Exercise 1:The Perogy Heaven Food Truck Co.

**Jacky runs a food truck business that produces many different flavours of perogies. Jacky inputs include: 3 trucks, insurance, gas, employees, food ingredients, cleaning supplies, and serving supplies (napkins, paper plates, and plastic utensils).**

**Which of the inputs would be fixed inputs?**

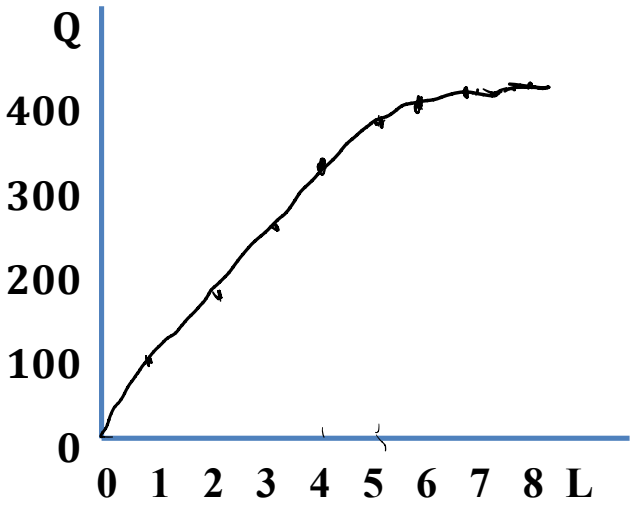
3 trucks, insurance

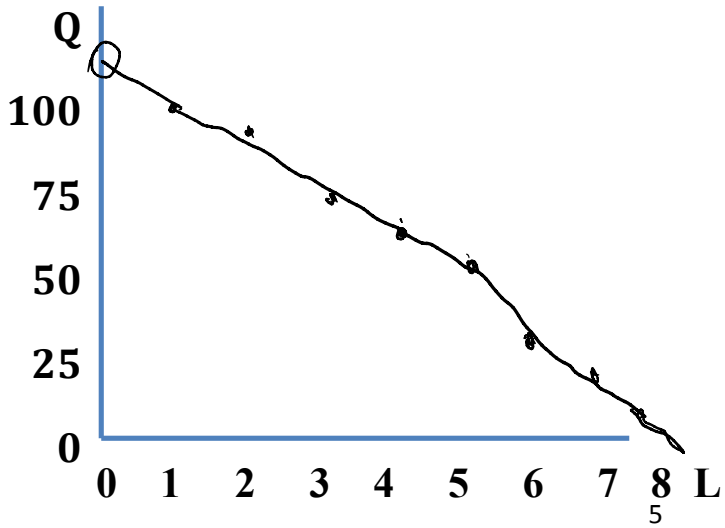
**Which of the inputs would be variable inputs?**

gas, employees, food ingredients, cleaning supplies, serving supplies

**Fill in the following table and graph the TP and MPL curves:**

| L | Q | MPL |
|---|---|---|
| 0 | 0 | |
| 1 | 100 | 100 |
| 2 | 185 | 85 |
| 3 | 255 | 70 |
| 4 | 310 | 55 |
| 5 | 350 | 40 |
| 6 | 375 | 25 |
| 7 | 385 | 10 |
| 8 | 385 | 0 |



# Cost Curves

**Cost curves show the relationship between quantity of output and costs of production.**

**Fixed Costs (FC)** = cost of the fixed input

- **Fixed costs** do not depend on the quantity of output
- **They must be paid no matter how much output is produced because the fixed input cannot change.**
- **Fixed costs are** sunk costs
- **E.g. Rent, insurance, vehicle lease payments**

**Variable Costs (VC)** = cost of the variable inputs

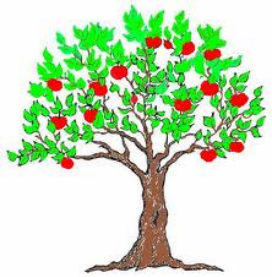
- **Variable costs** depend on the quantity of output
- **E.g. wages, food in a restaurant, gas for vehicles**

**Total Costs (TC)** = FC + VC

**Marginal Cost** = the additional cost of making one more unit. $MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta VC}{\Delta Q}$

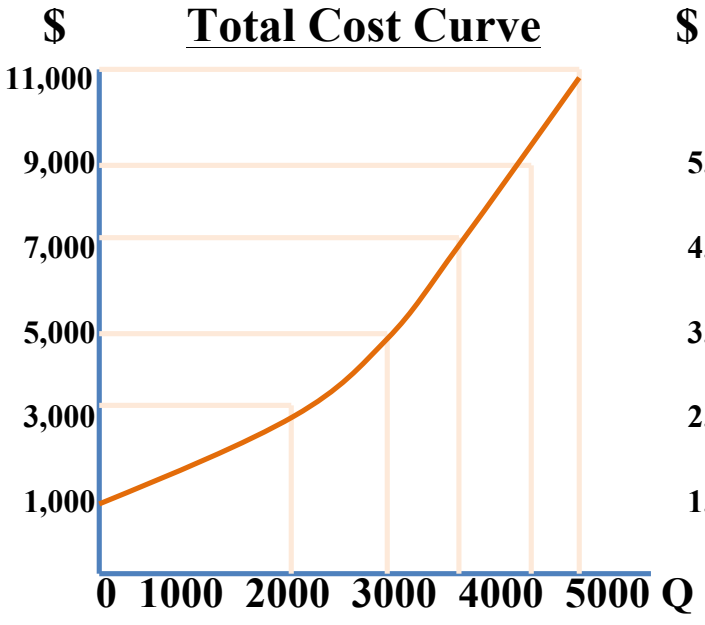
**Marginal costs consist of** variable costs, the costs that change when output increases by one unit.

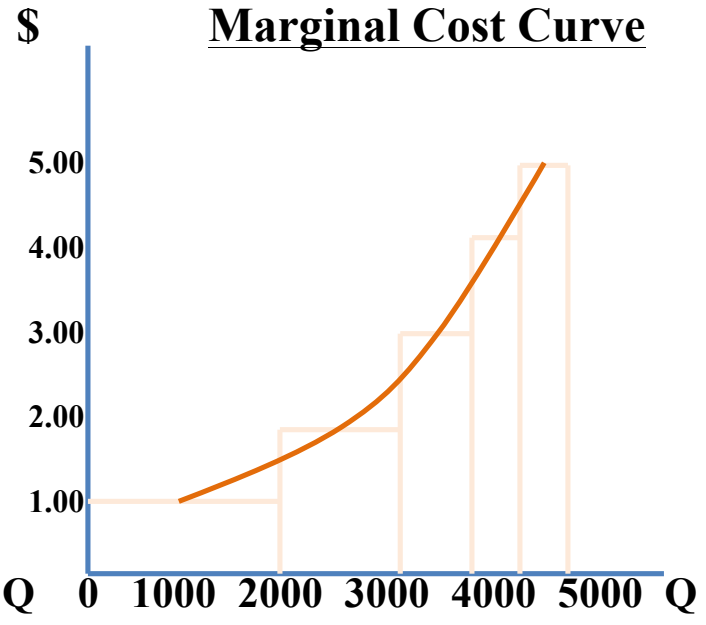
**Example: An Apple Farmer's Costs**



**The farmer must pay $1000 per month for the land, regardless of how much he grows, and the wage for a farm worker is $2000 per month.**

| L | Q | MPL | FC | VC | TC | MC |
|---|---|---|---|---|---|---|
| 0 | 0 | | 1000 | 0 | 1000 | |
| | | 2000 | | | | $\frac{2000}{2000}=1$ |
| 1 | 2000 | | 1000 | 2000 | 3000 | |
| | | 1000 | | | | $\frac{2000}{1000}=2$ |
| 2 | 3000 | | 1000 | 4000 | 5000 | |
| | | 667 | | | | $\frac{2000}{667}=3$ |
| 3 | 3667 | | 1000 | 6000 | 7000 | |
| | | 500 | | | | $\frac{2000}{500}=4$ |
| 4 | 4167 | | 1000 | 8000 | 9000 | |
| | | 400 | | | | $\frac{2000}{400}=5$ |
| 5 | 4567 | | 1000 | 10000 | 11000 | |



## Explaining the Shape of the Cost Curves:

- **The TC curve gets** increases **(slope increases) because** marginal costs increases

- **MC increases because the** MP of your variable inputs (labour) diminishes

- **The MP of your variable inputs diminishes because of the** fixed input (e.g. lands)

- **Each additional worker you hire will produce a smaller and smaller additional quantity of output.**

- **But you have to pay each worker the same → same additional costs.**

- **So each additional unit of production** costs more

Diminishing MP → rising MC

Flattening TP curve → steepening TC curve.

# Exercise 2:The Perogy Heaven Food Truck Co.

**Jacky's costs are as follows:**

**Rent and insurance per day per truck $100 (there are 3 trucks)**

**Wages per day for one employee $80**

**Ingredients and supplies per perogy serving $3**

**Fill in the table:**

| L | Q | MPL | FC | VC | TC | MC |
|---|---|---|---|---|---|---|
| 0 | 0 | | 300 | 0 | 300 | |
| 1 | 100 | 100 | 300 | 380 | 680 | 3.80 |
| 2 | 185 | 85 | 300 | 715 | 1015 | 3.94 |
| 3 | 255 | 70 | 300 | 1005 | 1305 | 4.14 |
| 4 | 310 | 55 | 300 | 1250 | 1550 | 4.45 |
| 5 | 350 | 40 | 300 | 1450 | 1750 | 5 |
| 6 | 375 | 25 | 300 | 1605 | 1905 | 6.2 |
| 7 | 385 | 10 | 300 | 1715 | 2015 | 11 |
| 8 | 385 | 0 | 300 | 1795 | 2095 | |

**Average Cost Curves** show how the average costs change as output increases

**Average Total Cost =** $ATC = \frac{TC}{Q}$

**Average Fixed Cost =** $AFC = \frac{FC}{Q}$

**Average Variable Cost =** $AVC = \frac{VC}{Q}$

## Exercise 3:The Perogy Heaven Food Truck Co.

**Fill in the table:**

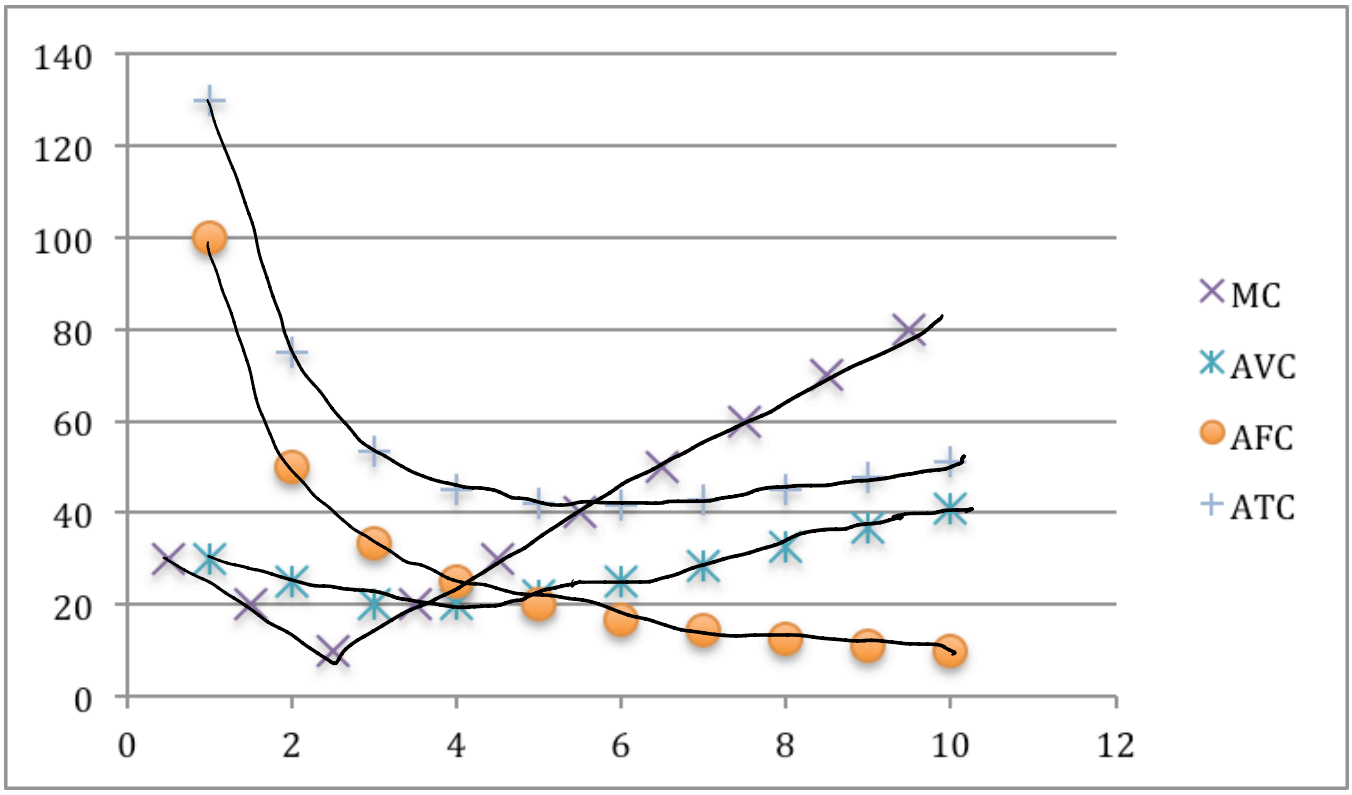
| Q | FC | VC | TC | MC | AFC | AVC | ATC |
|---|---|---|---|---|---|---|---|
| 0 | 300 | 0 | 300 | - | - | - | - |
| 100 | 300 | 380 | 680 | 3.80 | 3.00 | 3.80 | 6.80 |
| 185 | 300 | 715 | 1015 | 3.94 | 1.62 | 3.86 | 5.49 |
| 255 | 300 | 1005 | 1305 | 4.14 | 1.17 | 3.94 | 5.11 |
| 310 | 300 | 1250 | 1550 | 4.45 | 0.97 | 4.03 | 5.00 |
| 350 | 300 | 1450 | 1750 | 5.00 | 0.86 | 4.14 | 5.00 |
| 375 | 300 | 1605 | 1905 | 6.20 | 0.8 | 4.28 | 5.08 |
| 385 | 300 | 1715 | 2015 | 11.00 | 0.77 | 4.45 | 5.23 |
| 385 | 300 | 1795 | 2095 | - | 0.77 | 4.66 | 5.44 |

## Example: Costs of producing chairs

| Q | FC | VC | TC | MC | AVC | AFC | ATC |
|---|---|---|---|---|---|---|---|
| 0 | 100 | 0 | 100 | | - | - | - |
| | | | | 30 | | | |
| 1 | 100 | 30 | 130 | | 30 | 100 | 130 |
| | | | | 20 | | | |
| 2 | 100 | 50 | 150 | | 25 | 50 | 75 |
| | | | | 10 | | | |
| 3 | 100 | 60 | 160 | | 20 | 33.3 | 53.3 |
| | | | | 20 | | | |
| 4 | 100 | 80 | 180 | | 20 | 25 | 45.0 |
| | | | | 30 | | | |
| 5 | 100 | 110 | 210 | | 22 | 20 | 42.0 |
| | | | | 40 | | | |
| 6 | 100 | 150 | 250 | | 25 | 16.7 | 41.7 |
| | | | | 50 | | | |
| 7 | 100 | 200 | 300 | | 28.6 | 14.3 | 42.9 |
| | | | | 60 | | | |
| 8 | 100 | 260 | 360 | | 32.5 | 12.5 | 45.0 |
| | | | | 70 | | | |
| 9 | 100 | 330 | 430 | | 36.7 | 11.1 | 47.8 |
| | | | | 80 | | | |
| 10 | 100 | 410 | 510 | | 41 | 10 | 51 |

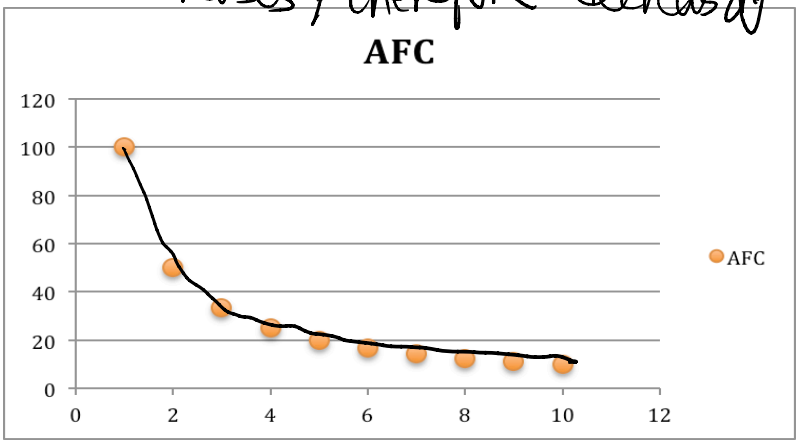


## Graphing the Marginal and Average Cost Curves



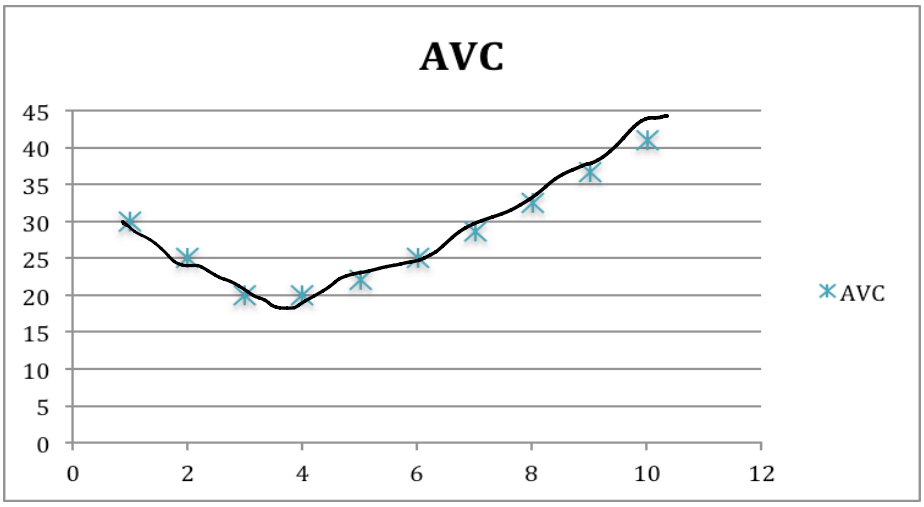

## Explaining the shapes of the curves:

***Spreading Effect:*** Average fixed costs decrease as output increases, therefore decreasing ATC.




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

***The Diminishing Returns Effect:*** Average variable costs increases as output increases because of diminishing marginal product. Therefor increasing ATC



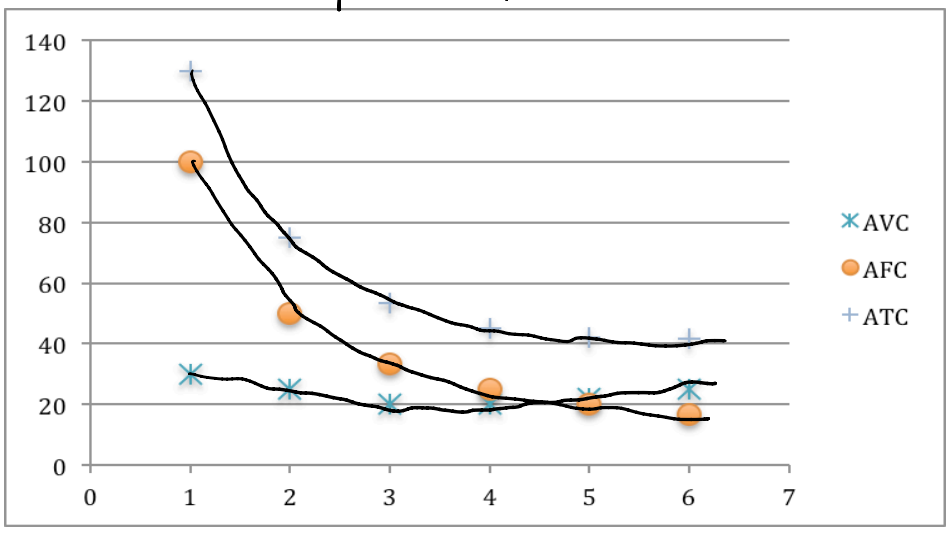

$AVC = \frac{VC}{Q}$

**Whichever effect is stronger (has a steeper slope) determines what happens to average total cost.**

***When the spreading effect is stronger than the diminishing returns effect:***

**→The decrease in AFC is greater than the increase in AVC.**

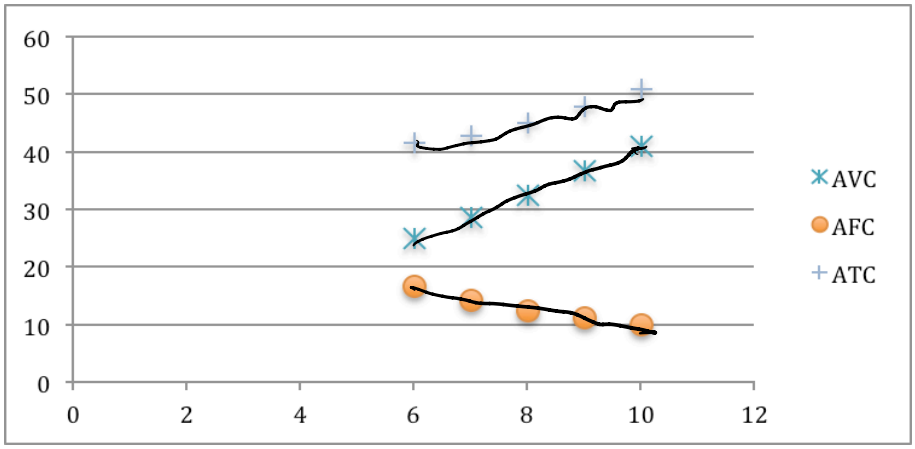
**→The ATC curve will** slope down



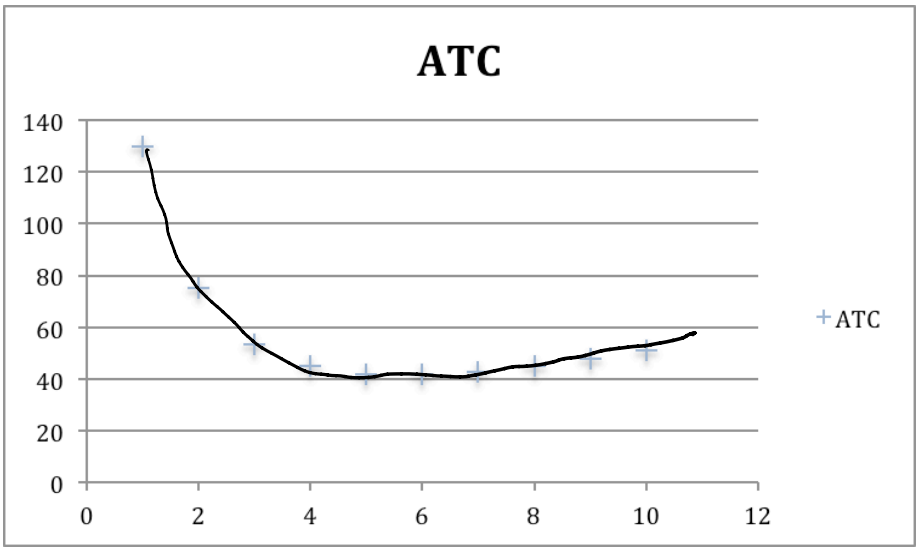
***When the diminishing returns effect is stronger than the spreading effect:***

**→The decrease in AFC is less than the increase in AVC.**

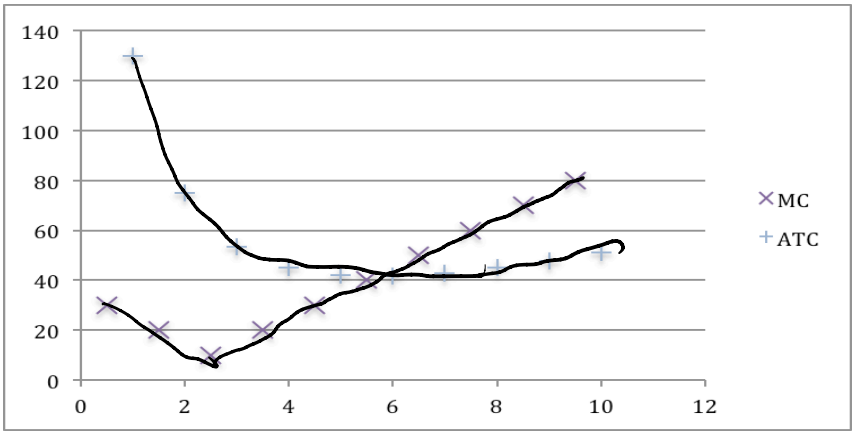
**→The ATC curve will**




**Together the two effects make the ATC curve U-shaped:**



# Marginal Cost and ATC Curves:




**Recall that when calculating an average number:**

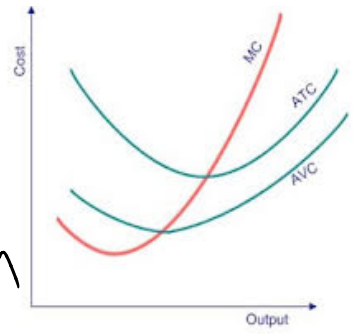
- **An additional big number will increase the average.**
- **An additional small number will decrease the average.**

**Average of (3,4,5) = (3+4+5)/3 = 4**

**Average of (3,4,5,6) = (3+4+5+6)/4 = 4.5**

**Average of (2,3,4,5) = (2+3+4+5)/4 = 3.5**

- **The ATC curve will be above the MC curve as long as the additional marginal cost of a unit of output brings down the average →** ATC decreases
- **When the MC curve is above the ATC curve additional marginal costs are increasing the average →** ATC increases
- **The ATC and AVC curves are normally U-shaped and** the MC curve crosses each at their lowest point.
- **The quantity of output where ATC is lowest is the** minimum-cost output
  - **At this point** MC=ATC



## Exercise 4:The Perogy Heaven Food Truck Co.

**Over what quantity range of perogy servings is the spreading effect stronger than the diminishing returns effect?** 0–310
**Over what quantity range of perogy servings is the diminishing returns effect stronger than the spreading effect?** 350–385
**What is the *minimum cost output* for Jacky?** 350
**At this point what is the ATC?** 5
**At this point what is the MC?** 5

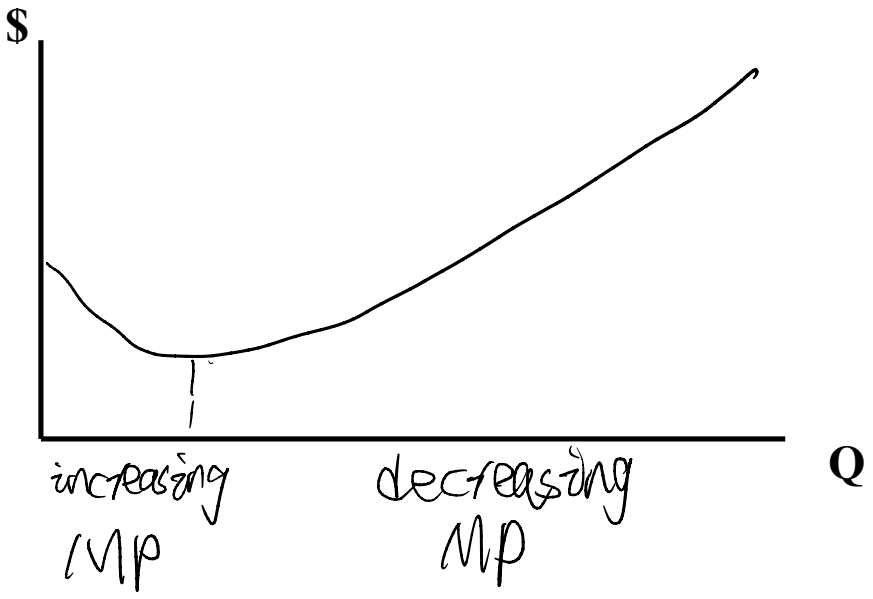
## More on the MC Curve:

**MC curves may slope down at very low levels of production if** the marginal product of labour increases.

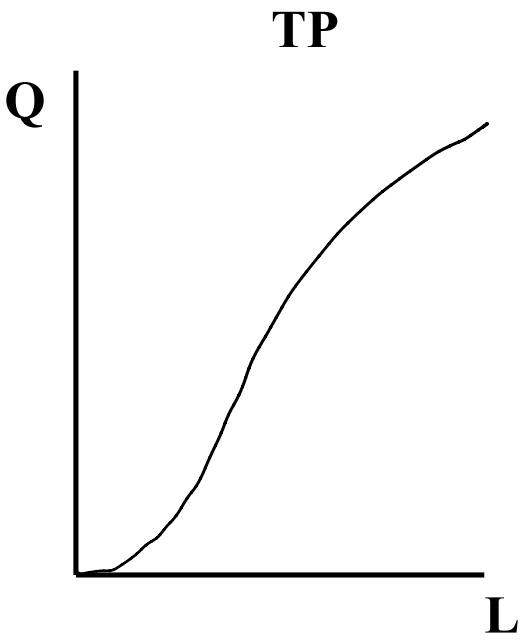
**This will happen if there is a substantial increase in *productivity* from an additional worker due to the benefits of** specialization.

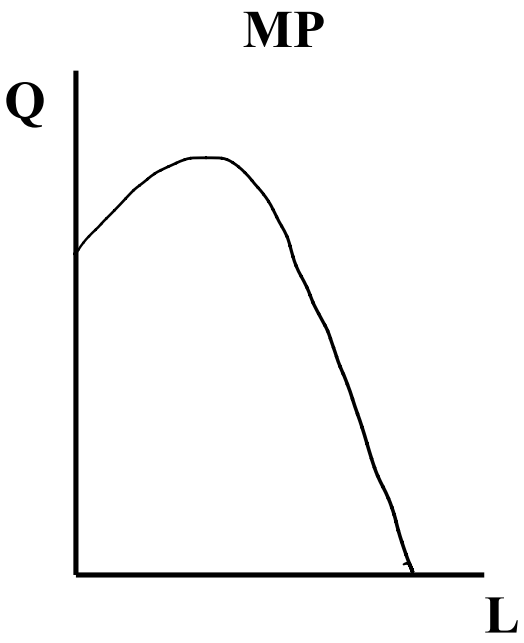
**E.g. A restaurant could more than triple production by increasing workers from 1 to 3. One worker can cook, one serve food, and one do the dishes rather than someone trying to do all three tasks.**

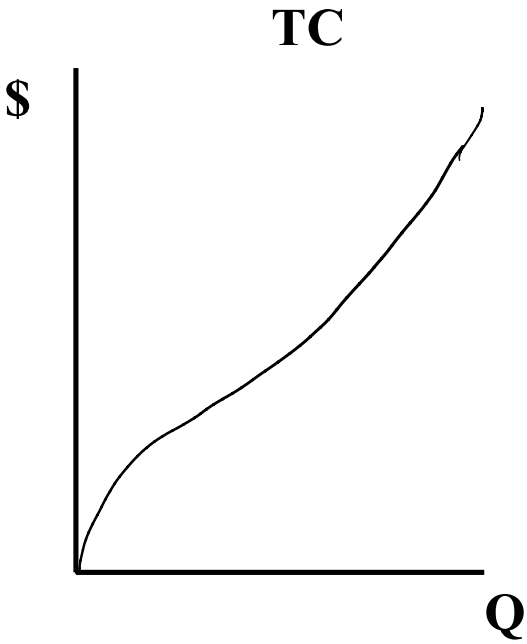
**Typical MC curve:**

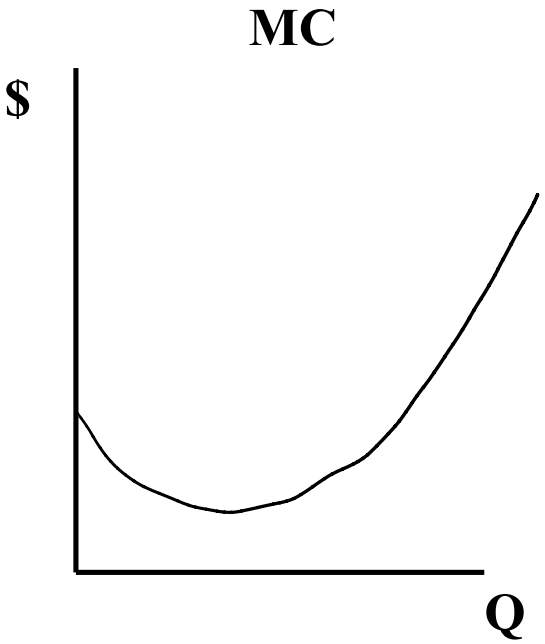


**Summary:**



**Example with Equations:**

**A total cost function for producing a good is:**

$TC = 10 + Q + Q^2$

**Variable costs depend on the output produced, so the variable cost function is:** $Q^2 + Q$

**Fixed costs are not dependent on output. So the fixed costs are:**

$FC = 10$

**The average total cost function is:**

$\frac{Q^2+Q+10}{Q} = Q + 1 + \frac{10}{Q}$

**The average fixed cost function is:**

$\frac{10}{Q}$

**The average variable cost function is:**

$Q + 1$

**The average costs of producing 2 units of output are:**

$ATC = \frac{10}{2} + 1 + 2 = 8$

$AFC = \frac{10}{2} = 5$

$AVC = 1 + 2 = 3$

# Exercise 5: Total Cost Function

**The total and marginal cost functions for a firm are:**

$$TC = 50 + 5Q + 0.2Q^2$$

$$MC = 5 + 0.4Q$$

**What are the average cost functions?**

$ATC = \frac{1}{5}Q + 5 + \frac{50}{Q}$

$AVC = \frac{1}{5}Q + 5$

$AFC = \frac{50}{Q}$

**At what quantity is ATC = MC?**

$\frac{1}{5}Q + 5 + \frac{50}{Q} = 5 + \frac{2}{5}Q$

$\frac{50}{Q} = \frac{Q}{5}$

$Q^2 = 250$

$Q = 5\sqrt{10}$

**What is this quantity called?**

The minimum cost output

## Summary of Short Run Cost Calculations

| | | |
|---|---|---|
| Total fixed costs | FC | Costs that are the same at all output levels |
| Total variable costs | VC | Costs that vary with output |
| Total cost | TC | Sum of variable and fixed costs |
| Marginal costs | MC | Extra cost of producing one more unit |
| Average total cost | ATC | TC per unit of output (TC/Q) |
| Average fixed cost | AFC | FC per unit of output (FC/Q) |
| Average variable costs | AVC | VC per unit of output (VC/Q) |

## Long Run Costs

**In the long run all inputs can be changed, so a firm can change its fixed inputs, which will** change the average total costs

- **E.g. Buying more land or buildings, renting more office space or machinery.**
- **This will** increase fixed costs **but the *productivity of workers will increase* if they have more of the fixed inputs to work with, so** marginal and variable costs will decrease.

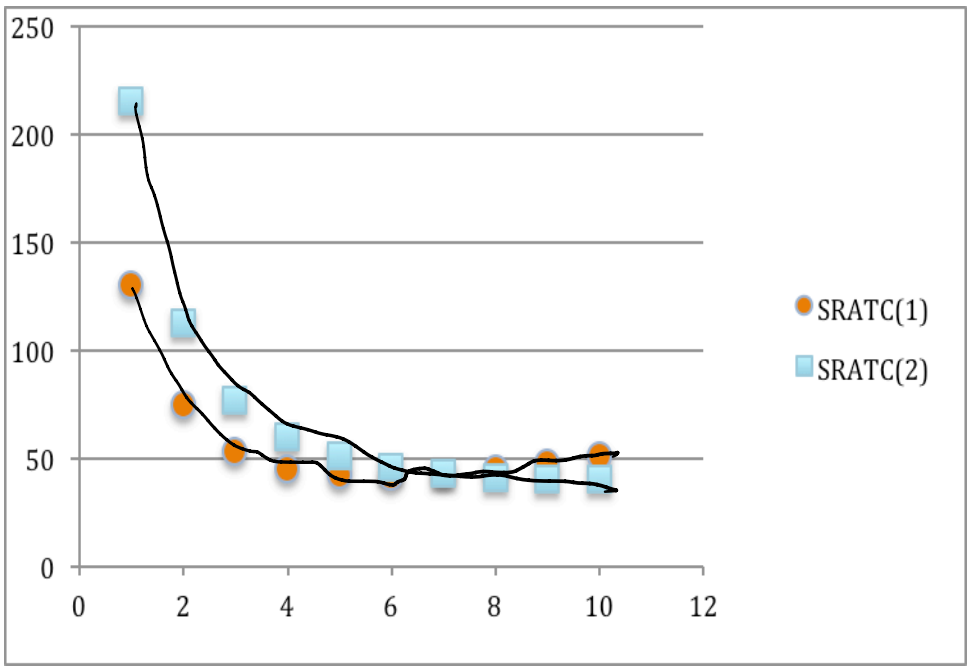
**Example: Costs of producing chairs**

**If the firm doubles its fixed inputs (factories) it can decrease its variable costs (wages) by one half.**

**The ATC for the two different quantities of fixed inputs are now called the *short run ATC curves* (SRATC).**

| Q | FC(1) | VC(1) | TC(1) | SRATC(1) | FC(2) | VC(2) | TC(2) | SRATC(2) |
|---|---|---|---|---|---|---|---|---|
| 0 | 100 | 0 | 100 | | 200 | 0 | 200 | |
| 1 | 100 | 30 | 130 | 130 | 200 | 15 | 215 | 215 |
| 2 | 100 | 50 | 150 | 75 | 200 | 25 | 225 | 112.5 |
| 3 | 100 | 60 | 160 | 53.3 | 200 | 30 | 230 | 76.7 |
| 4 | 100 | 80 | 180 | 45 | 200 | 40 | 240 | 60 |
| 5 | 100 | 110 | 210 | 42 | 200 | 55 | 255 | 51 |
| 6 | 100 | 150 | 250 | 41.7 | 200 | 75 | 275 | 45.8 |
| 7 | 100 | 200 | 300 | 42.9 | 200 | 100 | 300 | 42.9 |
| 8 | 100 | 260 | 360 | 45 | 200 | 130 | 330 | 41.3 |
| 9 | 100 | 330 | 430 | 47.8 | 200 | 165 | 365 | 40.6 |
| 10 | 100 | 410 | 510 | 51 | 200 | 205 | 405 | 40.5 |

## Graph of the SRATC curves:




**SRATC[1] is lowest when** Q≤7. The lower fixed costs outweight the higher variable costs.

**SRATC[2] is lowest when** Q≥7. The lower variable costs outweight the higher fixed costs.

**The amount of fixed input the firm chooses will depend on its output:**

- **If the firm only wants to produce Q ≤ 7 it is better off with one set of fixed inputs (SRATC[1] → one factory).**
- **If the firm wants to produce Q ≥ 7 it is better off with two sets of fixed inputs (SRATC[2] → two factories).**

**The long run ATC curve (LRATC)** shows the relationship between output level and ATC when fixed costs have been chosen to minimize ATC.

→ **All inputs are variable in the long run.**

## The Chair producer's Long Run ATC Curve

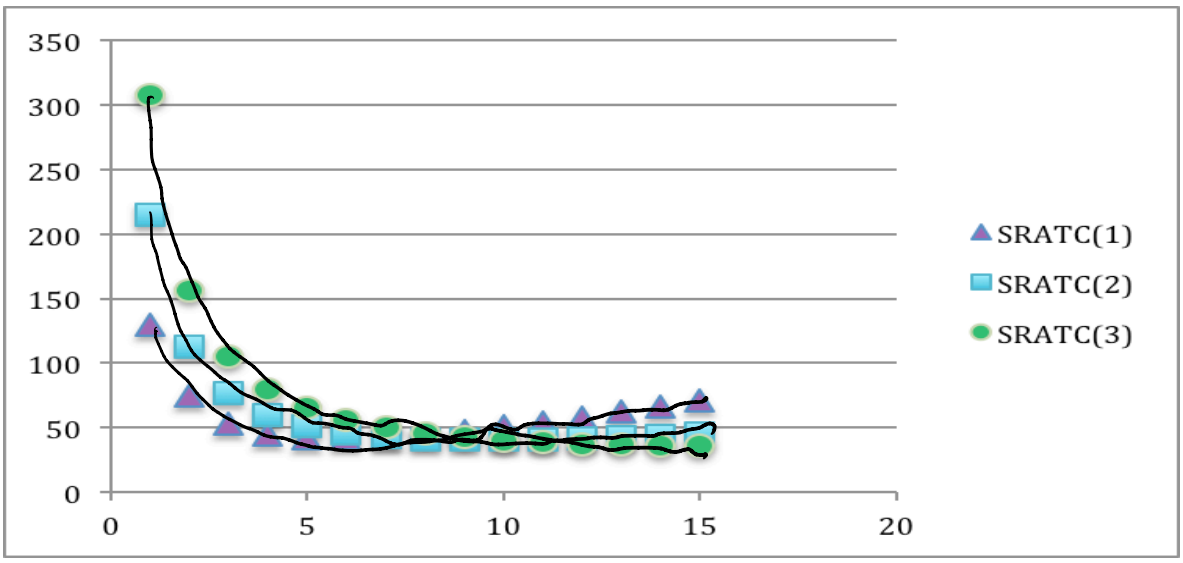
**$SRATC^1$ = 1 factory**

**$SRATC^2$ = 2 factories**

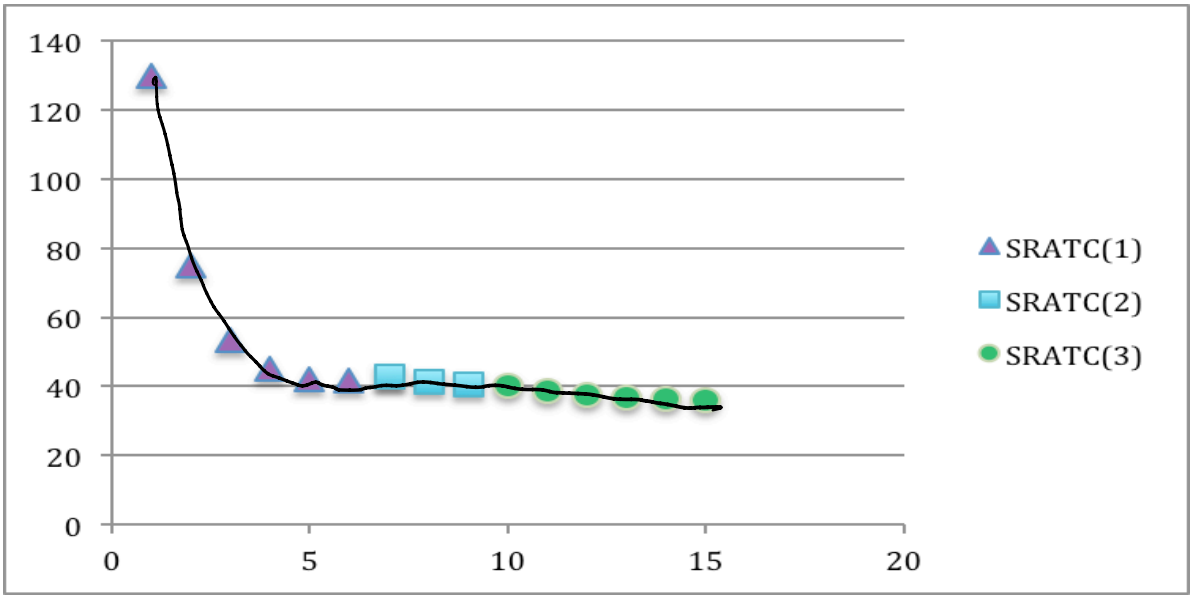
**$SRATC^3$ = 3 factories**

**The firm's LRATC is comprised of all the lowest point of its SRATC curves.**

| Q | SRATC(1) | SRATC(2) | SRATC(3) |
|---|---|---|---|
| 0 | | | |
| 1 | 130 | 215 | 307.5 |
| 2 | 75 | 112.5 | 156.3 |
| 3 | 53.3 | 76.7 | 105 |
| 4 | 45 | 60 | 80 |
| 5 | 42 | 51 | 65.5 |
| 6 | 41.7 | 45.8 | 56.3 |
| 7 | 42.9 | 42.9 | 50 |
| 8 | 45 | 41.3 | 45.6 |
| 9 | 47.8 | 40.6 | 42.5 |
| 10 | 51 | 40.5 | 40.3 |
| 11 | 54.5 | 40.9 | 38.6 |
| 12 | 58.3 | 41.7 | 37.5 |
| 13 | 62.3 | 42.7 | 36.7 |
| 14 | 66.4 | 43.9 | 36.3 |
| 15 | 70.7 | 45.3 | 36 |



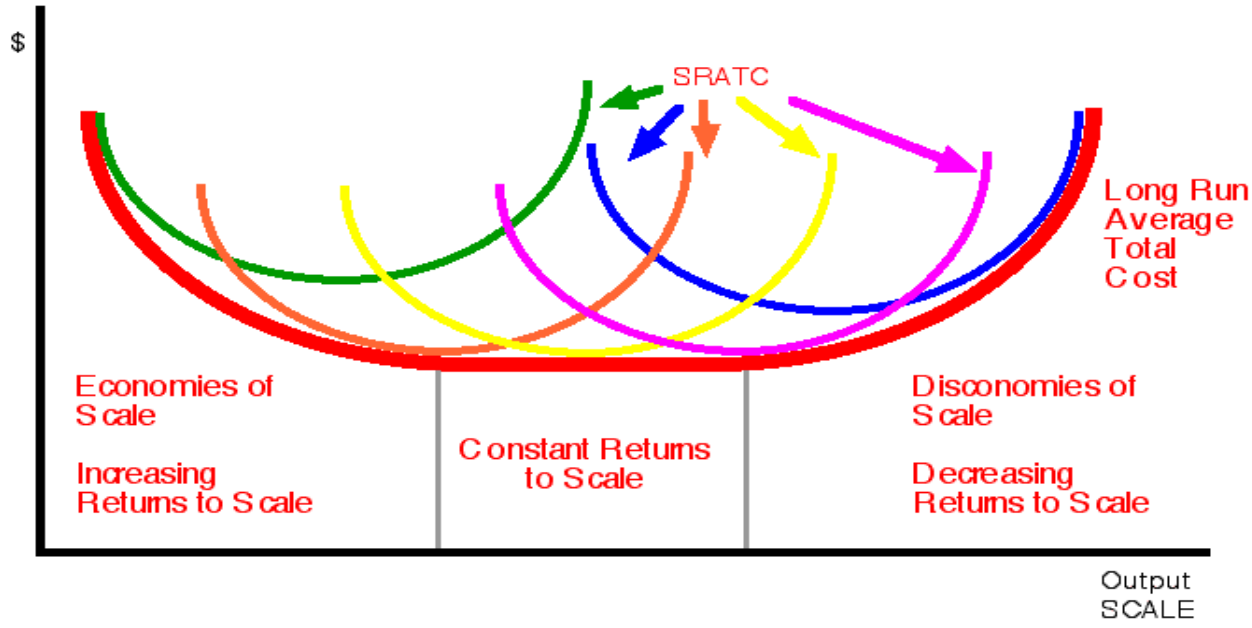

## The Chair producer's LRATC:




## What if the Firm wants to Change Output?

**In the short run, the firm must *move along the same short run curve*, but in the long run the firm can change its fixed inputs and *move to a different short run curve* to minimize costs.**

# A Typical Long Run ATC Curve:




## Why is the LRATC curve U-shaped?

**LRATC will decrease as output increases because a larger firm can allow its workers to specialize and become more productive.**

- **This is called** economies of scale or increasing returns to scale.

**If, when a firm gets too big, there are coordination and communication problems, then LRATC will increase.**

- **This is called** diseconomies of scale or decreasing returns to scale.

**If there are no changes to average total costs as a firm grows this is called** constant returns to scale.

## Exercise 6: Long Run Average Total Costs

**The following table shows average total costs for a coffee shop when they have a varying number of espresso machines.**

| Q | $ATC_1$ | $ATC_2$ | $ATC_3$ | $ATC_4$ |
|---|---|---|---|---|
| 0 | - | - | - | - |
| 100 | 300 | 350 | 400 | 450 |
| 200 | 275 | 330 | 370 | 420 |
| 300 | 250 | 300 | 340 | 380 |
| 400 | 225 | 270 | 310 | 340 |
| 500 | 250 | 240 | 280 | 310 |
| 600 | 275 | 210 | 250 | 280 |
| 700 | 300 | 240 | 220 | 250 |
| 800 | 325 | 270 | 190 | 220 |
| 900 | 350 | 300 | 220 | 190 |
| 1000 | 375 | 330 | 250 | 220 |

**If the coffee shop wants to produce 100 coffees how many espresso machines would be optimal in the long run?**

1 machine

**If the coffee shop wants to produce 400 coffees how many espresso machines would be optimal in the long run?**

1 machine

**If the coffee shop wants to produce 800 coffees how many espresso machines would be optimal in the long run?**

3 machines

**Suppose the coffee shop currently has 1 espresso machine and on average they are selling 100 coffees. The next Saturday is really busy and they sell 500 coffees. What is their ATC for that day?** 250

**If they continued to be busier every day and sell 500 coffees per day what would they do in the long run?**

They would get a second machine.

**Draw the coffee shop's *long run average total cost curve*.**