

Production Costs

Cost Curves and Input Quantities

There are three different cost curves --Total Cost (TC), Average Cost (AC), and Marginal Cost (MC).

To calculate costs, we consider Florence the Arkansas chicken farmer. Her costs depend on the amount of inputs she buys and on the prices of those inputs. In deriving costs, we assume that the price of corn is beyond Flo's control and that the quantities of all other inputs (other than corn) are held fixed.

Initially we ignore the costs of all other inputs and focus solely on corn, which costs \$10 for a 40-pound bag. The relevant information is shown in the table below.

TPP of chicken (lbs. per week)	Corn input (bags per week)	Total Cost (per week)	Average Cost (TC/Q of output)
0	0	0	0.00
14	1	10	0.71
36	2	20	0.56
66	3	30	0.45
100	4	40	0.40
130	5	50	0.38
156	6	60	0.38
175	7	70	0.40
184	8	80	0.43

For example, the total cost of producing 66 pounds per week is \$30.

TPP tells us how much output a firm can produce given the input quantities. From those input quantities and the price of inputs, the firm can determine the Total Cost of producing any level of output.

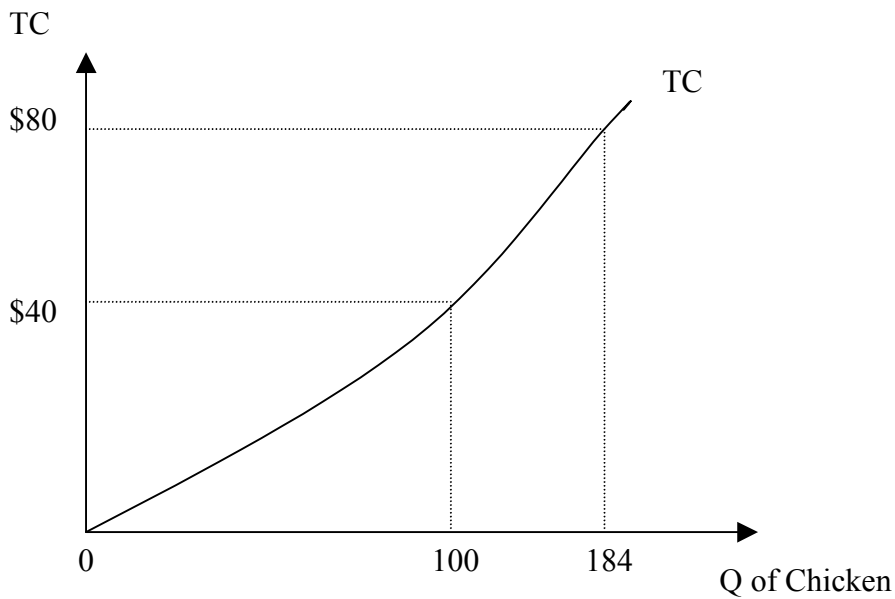
Total cost (TC) is the price of the inputs multiplied by the quantity of the inputs.

Average cost (AC) is the Total Cost divided by the quantity of the output. For example, the total cost of producing 100 pounds of chicken is \$40 so the AC is \$0.40 (or \$40/100).

Marginal cost (MC) is the change in TC resulting from a one unit increase in production. For example, if the cost of producing 100 pounds of chicken is \$40 while the cost of producing 99 pounds is \$39.70, then the MC of the 100th pound is \$0.30. The table above does not show this because output rises by more than 1 pound a week.

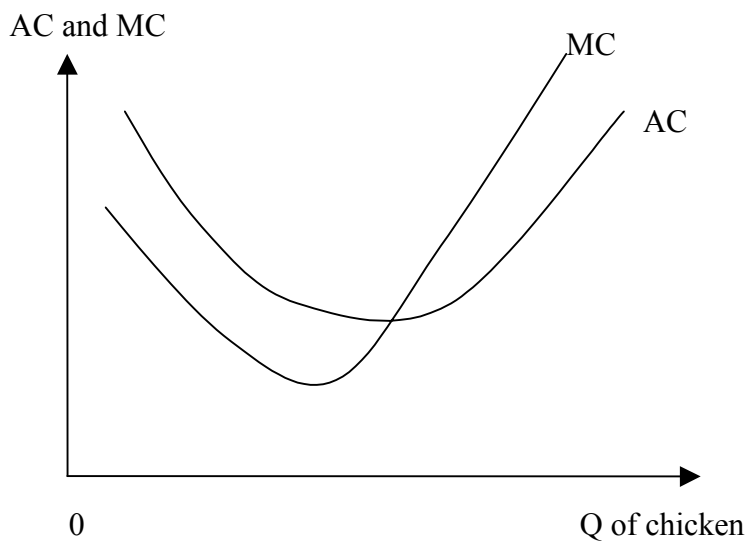
Shapes of the cost curves

Consider the graph of Total Cost.



TC rises as output rises. Obviously, the production of more chicken meat requires more corn, which costs additional money. TC rises slowly from 0 to 4 bags because the MPP of corn is increasing. Output rises quickly because each additional bag of corn contributes more chicken than the previous bag did, yet costs the same \$10. TC rises more rapidly after the 4th bag because diminishing MPP sets in. Thus, each additional bag contributes less meat than the previous bag did, yet costs the same \$10.

Consider a graph of Average Cost and Marginal Cost.



Average and marginal cost curves have a U shape. AC and MC typically fall and then rise as the level of output increases. The U shape comes from the law of diminishing MPP. AC and MC curves follow the shapes of the APP and MPP curves of the variable input.

$$AC = \frac{TC}{Q_{\text{output}}} = \frac{P_{\text{input}} \times Q_{\text{input}}}{Q_{\text{output}}} = P_{\text{input}} \times \frac{Q_{\text{input}}}{TPP} = P_{\text{input}} \times \frac{1}{APP_{\text{input}}}$$

AC tends to fall and then rise because the APP of an input tends to rise and then fall once diminishing marginal returns set in.

$$MC = \frac{\Delta TC}{\Delta Q_{\text{output}}} = P_{\text{input}} \times \frac{\Delta Q_{\text{input}}}{\Delta TPP} = P_{\text{input}} \times \frac{1}{MPP_{\text{input}}}$$

MC tends to fall and then rise because the MPP of an input tends to rise and then fall once diminishing marginal returns sets in.

Consider the relationship between these two curves. AC is falling if MC is falling and AC is rising if MC is rising. This relationship is easily explained by examining student grades --GPA is an average grade and PACE 310 is a marginal grade. If your 310 grade is higher (lower) than your GPA, then the marginal grade pulls your average grades up (down).

Fixed and Variable Costs

Total Cost, Average Cost, and Marginal Cost can be divided into 2 components --fixed costs and variable costs.

A fixed cost is the cost of an input whose quantity does not rise when output increases. It is an input that the firm requires to produce any output at all. The Total Cost of such indivisible inputs does not change when output changes. Any other cost of the firm's operations is a variable cost.

For example, it takes at least one taxi to run a cab company and the cost of the taxi is the same whether 1 or 60 people ride in it. However, the gasoline to run the cab rises as more people ride in it. The gasoline is a variable cost --one that increases as the level of output rises.

Another example, the railroad running between Los Angeles and San Diego requires a whole set of tracks; not 1/4 or 1/2 but 1, which is indivisible. For any output greater than zero, the railroad must build the track. The cost of the track is the same if 3 trains run every day or only once a week. Construction costs to build the track do not vary with the volume of traffic. But, as more trains pass over the tracks the railroad will have a higher fuel bill, which is a variable cost.

Question: What are the fixed and variable costs of the firm that you work for?

Definitions

Total Cost = Total Variable Cost (TVC) + Total Fixed Cost (TFC)

Average Cost = Average Variable Cost (AVC) + Average Fixed Cost (AFC)

$$\begin{aligned}AC &= TC/Q \text{ of output} \\AVC &= TVC/Q \text{ of output} \\AFC &= TFC/Q \text{ of output}\end{aligned}$$

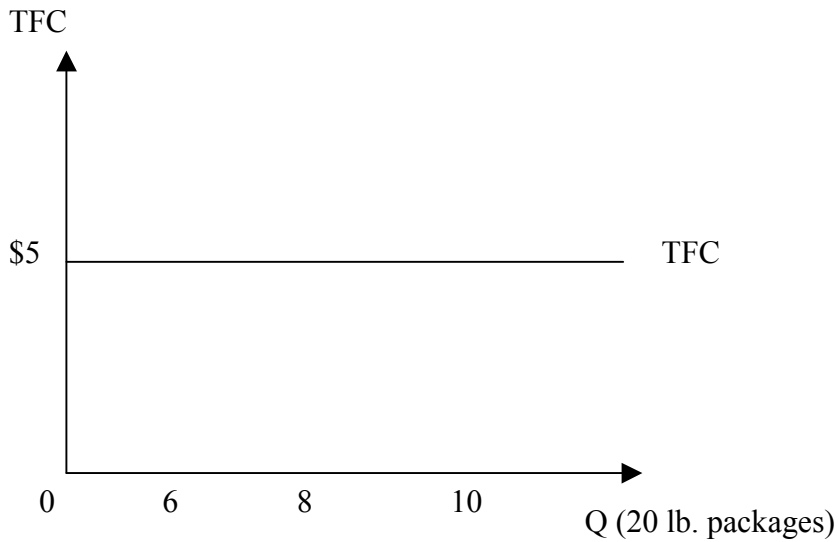
Say Flo has 2 costs --feed and rent. She must buy corn for \$10 a bag to feed her chickens and rents her chicken coop for \$5 a week. The relevant weekly cost information is shown in the table below.

Output (20 lb. packages)	TVC	TFC	TC	MC	AVC	AFC	AC
0	0.0	5.0	5.0	---	---	---	---
1	17.0	5.0	22.0	17.0	17.0	5.0	22.0
2	26.0	5.0	31.0	9.0	13.0	2.5	15.5
3	33.0	5.0	38.0	7.0	11.0	1.7	12.7
4	40.0	5.0	45.0	7.0	10.0	1.25	11.25
5	48.0	5.0	53.0	8.0	9.6	1.0	10.6
6	57.0	5.0	62.0	9.0	9.5	0.8	10.3
7	67.2	5.0	72.2	10.2	9.6	0.7	10.3
8	80.0	5.0	85.0	12.8	10.0	0.6	10.6
9	99.0	5.0	104.0	19.0	11.0	0.56	11.6
10	125.0	5.0	130.0	26.0	12.5	.50	13.0

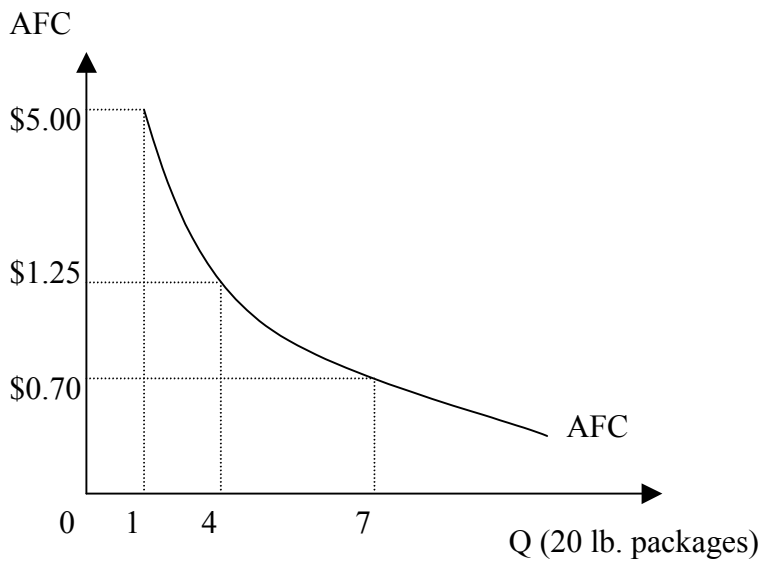
Notice that the first 3 columns are used to derive the remaining 5 columns.

The rent of \$5 is her TFC and it remains constant regardless of the number of 20 lb. packages that she produces.

The graph of TFC is a horizontal line at \$5.



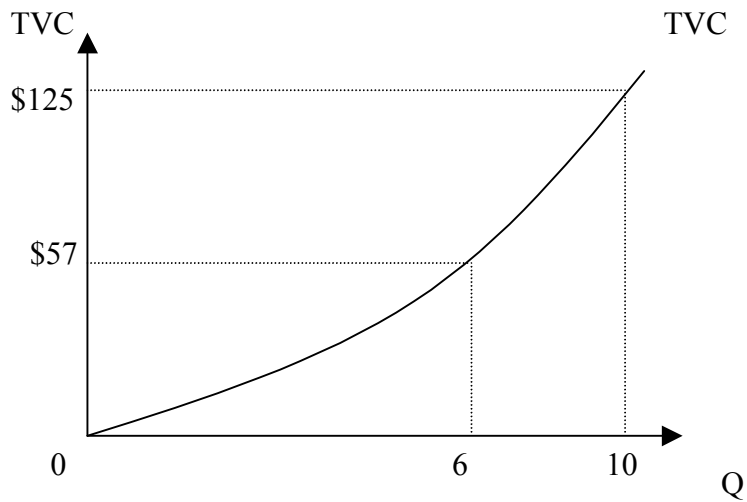
AFC has a more interesting shape. It falls as the production of packages rises.



If Flo produces one 20 lb. package of chicken, the entire fixed cost is carried by 1 package. But if she produces 4 packages, the fixed cost gets divided between the 4 packages. In this way, AFC falls as the output rises.

Question: When does AFC reach zero?

TVC has the same shape as TC because variable costs rise as output increases.



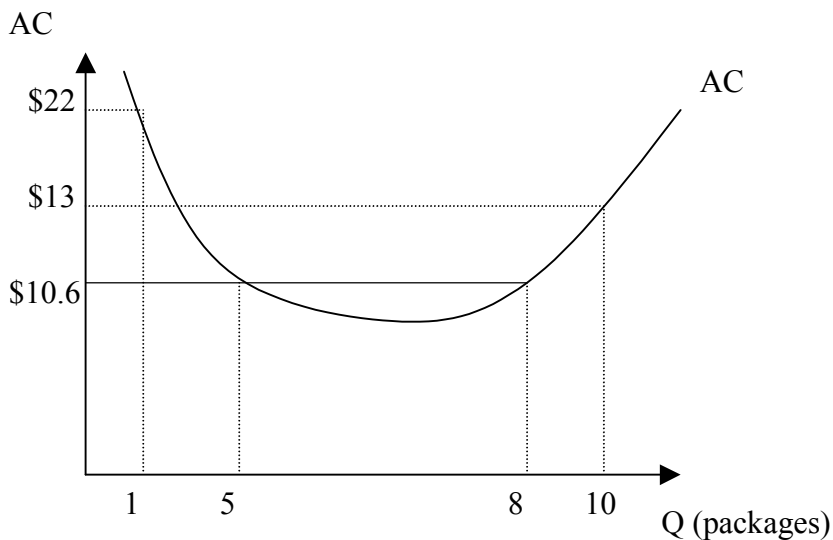
Consider one last definition:

Marginal Cost = Marginal Variable Cost (MVC)

Question: Why doesn't MC have a fixed component (i.e., marginal fixed cost)?

Shape of the Average Cost Curve Revisited

AC is generally U shaped --it initially declines and eventually rises with the level of output.



AC declines for 2 reasons:

- (1) Changing input proportions: at first Flo feeds the chickens more corn while holding all other inputs constant. Output increases rapidly when the MPP of corn is rising, which tends to lower AC.

(2) Fixed costs are falling as output rises.

AC eventually rises for 2 reasons:

- (1) Law of diminishing MPP: output rises more slowly as the MPP of corn begins to fall, which tends to raise AC.
- (2) Bureaucratic mess: as firms grow in size they lose the personal touch of management and become increasingly bureaucratic and impersonal, which drives costs higher.

The point at which AC starts to rise varies from industry to industry. The AC in the auto industry begins rising after more units of output than farming. The largest farm is tiny compared to the smallest automobile company. This is because of the large fixed costs involved in building cars. Automobile production requires a huge investment in plants, robots, and assembly lines. Thus, AFC is falling over more units of output, which pulls AC down.

The minimum efficient scale is the scale of operations at which AC reaches a minimum. If the minimum efficient scale occurs at large units of output, a few large-scale producers will dominate the industry.

$$\text{Recall that } AC = \frac{TC}{Q_{\text{output}}} = \frac{P_{\text{inputs}} \times Q_{\text{inputs}}}{Q_{\text{output}}}.$$

Industries that are comprised of a few large-scale producers (like automobiles) typically have increasing returns to scale (IRTS). IRTS gives a cost advantage to large producers because AC is falling as output expands.

Industries that are comprised of many small sellers (like farming) typically have decreasing returns to scale (DRTS). DRTS gives a cost advantage to smaller firms because AC is rising as output expands. DRTS indicates that the quantity of output less than doubles when the quantity of all inputs is doubled. This implies that AC is rising over the range of output.

Constant returns to scale (CRTS) is the intermediate case where AC is constant.

Long Run and Short Run Costs

The cost of changing a firm's output level depends on the period of time under consideration. At any point in time, many input choices are precommitted by past decisions. If a firm bought machinery 1 year ago, it is committed to that decision for the life of the machinery, unless the firm is willing to take the loss of getting rid of it sooner.

A sunk cost is a cost to which a firm is precommitted for some limited period of time. The firm may have signed a contract to make payments or already paid for some durable item (say machinery) and can't get its money back except by using that item to produce output for some period of time. Whether or not a cost is sunk depends on the planning horizon of a particular decision.

For example, a 2-year-old machine with a 9-year economic life is a variable cost after 7 years because the machine would have to be replaced in any case.

Economists often speak of the short run (SR) and the long run (LR). In the short run, some of the firm's cost commitments will come to an end. But in the long run, all of the firm's cost commitments come to an end.

The size of a firm may be fixed in the SR because it has purchased or leased a particular plant, but the firm can alter the size of its plant and capacity in the LR.

For example, Flo has already built a chicken coop, which gives her little opportunity to adjust the number of chickens she produces in the SR. But over a longer time period, Flo can build a new larger chicken coop if she wants to produce more chicken.

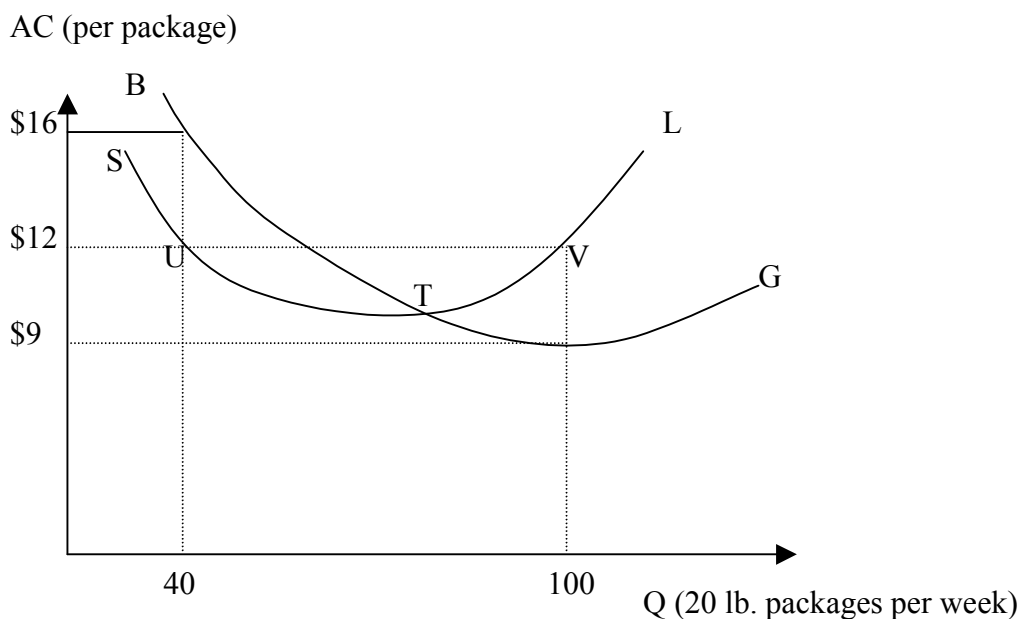
Different inputs can be altered at different times. For example, if the number of workers can be altered daily, and the number of machines altered yearly, and the size of the plant every 10 years. Then 10 years is the long run.

Average Cost in the SR and LR

All costs depend on the firm's planning horizon. The AC (and TC) curve for the long run differs from that of the short run because in the long run all inputs become variable.

There are no fixed costs in the long run. All costs are variable in the long run.

In the SR, Flo can only choose how many chickens to squeeze into her chicken coop. But in the LR, she can choose among different coop sizes. Consider the diagram of AC below.



Suppose that Flo initially expected to produce 40 packages of chicken per week so she purchased a coop corresponding to the AC of SL. Producing 40 packages, she has an AC of \$12 (point U). Now suppose she is pleasantly surprised by a higher than expected demand and she is able to sell 100 packages of chicken per week with an AC of \$12 (point V). She may wish that she had purchased the bigger coop with the corresponding AC curve of BG with its lower AC of \$9 per week. In the SR, Flo is stuck with the AC curve SL. In the LR, she can replace her coop and the relevant AC curve is STG.

The long run AC curve shows the lowest possible short run AC corresponding to each output level.