

We have mentioned that supply curve reflects cost of production.

This chapter discusses firms' costs in more detail.

Firm's costs are important determinant of production and pricing decisions.

An example of a firm: Helen's cookie factory.

Purpose of the firm is to maximize profits.

Profit = total revenue - total cost

Total revenue is amount firm gets paid for the sale of its cookies.

Total cost is amount firm must pay for inputs, including opportunity cost.  
Total revenue is easy to calculate. Total cost more difficult.

Firms' costs of production include all opportunity costs of making good.

Some opportunity costs obvious. If she spends \$1000 on flour, she can't spend that \$1000 on something else. Same for cost of firm's workers.

Costs for which the firm pays out money are explicit costs.

Costs for which the firm doesn't pay money are implicit costs. Suppose she has computer skills, could earn \$100 per hour as programmer. Then \$100 per hour is an implicit cost.

total costs are explicit costs plus implicit costs.

Difference between accounting cost and economic cost: accounting costs are the explicit costs only. Economic costs are both explicit and implicit costs.

Because to analyze how firms make production and pricing decisions, economists need to know the opportunity costs. For instance if Helen's potential wage as a computer programmer rises to \$500 an hour, she may sell or shut down the cookie factory.

Accountants interested in how much money flows in and out of firm, so don't need to know opportunity costs.

A special opportunity cost: The cost of capital

The cost of financial capital that is invested in a business.

This is what the capital would have earned as interest if it had been invested.

Suppose Helen used \$300,000 in savings to buy cookie factory.

If the money deposited in savings account with 5 percent interest rate, would have earned 15,000 per year.

Owning cookie factory costs her 15,000 a year in income – one of the opportunity costs.

Economist views this as a cost, accountant does not.

Suppose Helen did not have enough to buy the \$300,000 factory, had to borrow some.

Used \$100,000 of own savings, borrowed \$200,000 from bank at 5 percent interest rate.

Economic cost is still \$15,000 a year. Some of it is now explicit and some implicit. The opportunity cost of owning the business equals interest on loan (an explicit cost of \$10,000 per year) plus the interest forgone on savings (an implicit cost of \$5000 per year).

Economic Profit and Accounting Profit

Economic costs differ from accounting costs *rightarrow* economic profits differ from accounting profits.

Economic profits equal total revenue minus opportunity costs (explicit and implicit) of producing the good.

Accounting profits equal total revenue minus explicit costs.

Economic costs are larger than accounting costs  $\rightarrow$  economic profits smaller.

But firms motivated by economic profit. A firm making positive economic profit will stay in business.

### Production and Costs

How does the amount of production determine total cost?

Assume that Helen can't increase size of factory (we are looking at short-run). Quantity of cookies produced can be varied only by varying number of workers employed.

Workers	Q	MPL	Factory Cost	Worker Cost	Total Cost
0	0	-	30	0	30
1	50	50	30	10	40
2	90	40	30	20	50
3	120	30	30	30	60
4	140	20	30	40	70
5	150	10	30	50	80
6	155	5	30	60	90

The relationship between number of workers (input) and number of cookies produced (output) is the production function.

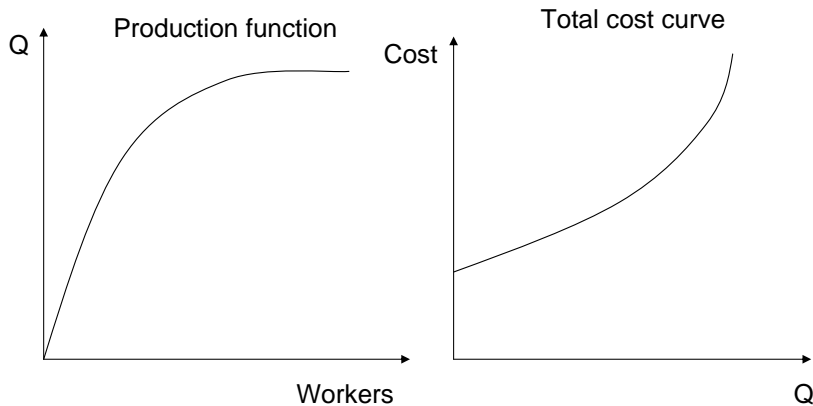
The third column, marginal product of labor shows the increase in cookie production due to an additional worker. For this example workers have diminishing marginal product – each successive worker increases production by a smaller amount. This is due to crowding.

Marginal product is the slope of the production function – the change in output divided by change in input.

In other examples, there may be increasing marginal product at first, but usually marginal product eventually starts to decrease. The initially increasing marginal product may be due to increasing possibility of specialization in tasks.

The total cost curve shows total cost as a function of quantity produced.

The production function and the total cost function in this example look like this:



Compare the total cost curve with the production function. Total cost is the fixed cost (\$30) of the factory plus the cost of the workers. Cost of the workers is proportional to (\$10 times) the number of workers.

So, looking at the production function sideways (with number of workers hired on the vertical axis and quantity on the horizontal axis) gives you the shape of the total cost curve. So these two curves describe the same thing.

Another way to describe the curves: When not many cookies are being produced, kitchen is not crowded, so cost of producing additional cookie is low. When many cookies are being produced, kitchen must be crowded, so cost of producing additional cookie is high. Additional workers do not contribute much to cookie-making because of crowdedness when number of cookies being made is high.

### Measures of cost

Q	TC	FC	VC	AFC	AVC	ATC	MC
0	3.00	3.00	0.00	-	-	-	-
1	3.30	3.00	0.30	3.00	0.30	3.30	0.30
2	3.80	3.00	0.80	1.50	0.40	1.90	0.50
3	4.50	3.00	1.50	1.00	0.50	1.50	0.70
4	5.40	3.00	2.40	0.75	0.60	1.35	0.90
5	6.50	3.00	3.50	0.60	0.70	1.30	1.10
6	7.80	3.00	4.80	0.50	0.80	1.30	1.30
7	9.30	3.00	6.30	0.43	0.90	1.33	1.50
8	11.00	3.00	8.00	0.38	1.00	1.38	1.70
9	12.90	3.00	9.90	0.33	1.10	1.43	1.90
10	15.00	3.00	12.00	0.30	1.20	1.50	2.10

The table shows different kinds of cost for Thelma's Lemonade Stand.

Like Helen's Cookie Factory, Thelma's has a total cost curve that gets steeper as quantity of output increases. This is also seen in the fact that marginal cost (change in cost for a one-glass increase in lemonade) is increasing as quantity of lemonade increases.

Two types of costs: fixed costs and variable costs. Fixed costs don't change when the amount of output changes. In short run, this includes rent for factory because rent for factory is fixed in short run.

Variable costs change when amount of output changes. Examples: Costs of lemons, sugar, cups and straws, and costs of workers.

Total cost is sum of fixed and variable costs.

Average and marginal costs

How much does it cost to make the typical cup of lemonade? This is answered by the average cost.

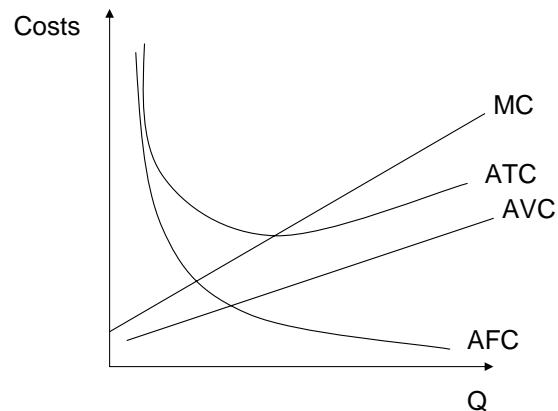
How much does it cost to make an additional cup of lemonade? This is answered by the marginal cost.

Average cost is total cost divided by quantity,  $AC = TC/Q$ .

Marginal cost is change in total cost divided by change in quantity,  $MC = \Delta TC/\Delta Q$ . Marginal cost tells us the increase in total cost due to an additional

unit of production.

## Shapes of Cost Curves



Features in common with many firms:

1. Marginal costs eventually rise – marginal costs may start by falling, but at some point they begin to rise.

In this case, marginal costs are rising from the beginning. This is because when she has small number of workers, marginal product of an additional worker is large, so marginal cost of an additional glass of lemonade is small.

When she has large number of workers, marginal product of an additional worker is small, so she needs to hire many workers (at a high cost) to produce an additional glass of lemonade.

2. U-shaped average total cost curve

Average total cost is the sum of average fixed cost and average variable cost. Average fixed cost decreases because divide a fixed number by higher and higher

level of output. Average variable cost eventually increases due to diminishing marginal product.

At low levels of output average total cost high because average fixed cost high.

At medium levels of output average total cost low because average fixed cost has fallen and average variable cost has not risen by much.

At high levels of output average total cost high again because average variable cost has risen.

Minimum of average total cost curve called efficient scale of the firm. For Thelma efficient scale is 5 or 6 glasses, minimum ATC is \$1.30.

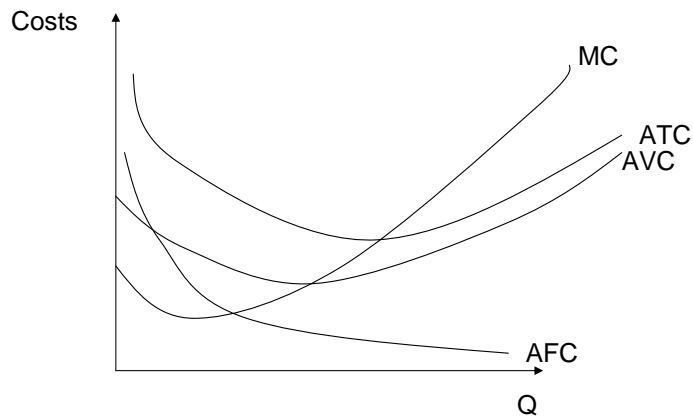
### 3. Relationship between MC and ATC, between MC and AVC

When marginal cost is less than average total cost, average total cost is falling. When marginal cost is more than average total cost, average total cost is rising. When marginal cost equals average total cost, average total cost is at its minimum.

Like for grades: if grade in next course (marginal grade) is higher than GPA, GPA will rise. If grade in next course is lower than GPA, GPA will fall.

Similarly for average variable cost. The MC curve crosses the ATC and AVC curves at their minima (if they exist) because once it lies above them they start to rise.

## Typical cost curves



In this graph, the first few workers have increasing marginal product. Thus marginal costs decrease initially.

Properties shared:

Marginal cost eventually rises with output

Average total cost curve is U-shaped

Marginal cost curve crosses ATC and AVC curves at their minima

Suppose Honda's total cost of producing 4 cars is \$225,000 and its total cost of producing 5 cars is \$250,000. What is the average total cost of producing 5 cars? What is the marginal cost of the 5th car?

Long-run and short-run costs

Firm's costs – which costs are variable and which are fixed – depend on the time horizon. Over a longer period of time, more costs are variable. In the very long run, all costs are variable.

Over a few months, Ford Motor Company can't change the size or number of its factories.

To make more cars over a period of a few months, Ford can only hire more workers.

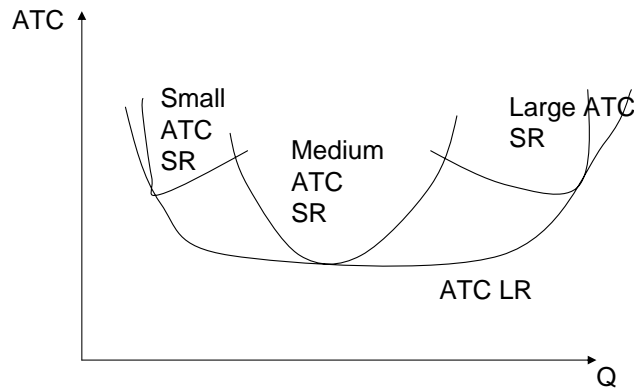
Cost of factories is a fixed cost in short run.

Over long run (several years), Ford can expand size and number of factories or close factories.

Cost of factories variable cost in long run.

Firm's long-run cost curves different from short-run cost curves.

Example:



Graph shows three short-run average cost curves for a small, medium and large factory (there are many possible short-run average cost curves, one for each size of factory), one long-run average cost curve.

There is only one long-run average cost curve because any size of firm can be built in the long run. The short-run average cost curves depend on the size of the firm already built.

Relationship between short-run and long-run costs:

1. Long-run average cost curve has flatter U-shape than all the short-run average cost curves. This is because in the long-run, the firm can choose the factory size that gives the desired output at minimum cost. In the short-run, the firm cannot choose factory size.

2. The short-run curves lie on or above the long-run curve. This is for the

same reason as 1. The short-run costs cannot be less than the long-run costs because over the long run, the firm has more choices as to factory size.

When Ford wants to increase production from 1000 to 1200 cars per day in the short run, it must hire more workers to work in the medium size factory. Due to diminishing marginal product, average total cost rises from 10,000 to 12,000 per car.

In long run, firm can expand both factory size and size of work force. Average total cost returns to 10,000 because the diminishing marginal product problem isn't there with a bigger factory.

The amount of time that constitutes the long run differs between firms. For a car manufacturer it may take more than a year to build a larger factory.

#### Economies and Diseconomies of Scale

There are economies of scale when long-run average total cost decreases as output increases.

There are diseconomies of scale when long-run average cost increases as output increases.

There are constant returns to scale when long-run average cost stays the same as output increases.

In the example above, Ford has economies of scale at low levels of output, constant returns to scale at medium levels of output, and diseconomies of scale at high levels of output. This pattern is typical of many firms.

Economies of scale occur when hiring more workers allows specialization in different tasks.

If Ford produced a small number of cars, it could not use assembly-line production, where each person is totally specialized in one task. The average costs would be higher.

Diseconomies of scale can happen because of coordination problems when firm is very large. Management may have difficulty keeping track of all operations of the firm.

That is why there isn't just one big firm.

At low levels of production, specialization is advantageous, no coordination problem → economies of scale.

At high levels of production, all gains from specialization have already been made, coordination becomes a problem → diseconomies of scale.

If Boeing produces 9 jets per month, its long-run total cost is \$9.0 million per month. If it produces 10 jets per month, its long-run total cost is \$9.5 million per month. Does Boeing exhibit economies or diseconomies of scale?

#### Firms in Competitive Markets

Market is competitive if

1. Each buyer and seller has little ability to influence market prices.
2. Little or no differentiation among goods.
3. Firms can freely enter or exit market.

Competitive firm maximizes revenue minus cost. First consider revenue.

Q	P	TR	AR	MR
1	6	6	6	-
2	6	12	6	6
3	6	18	6	6
4	6	24	6	6
5	6	30	6	6
6	6	36	6	6
7	6	42	6	6
8	6	48	6	6

Since price is the same for all units of the good, average revenue is the price of the good.

For competitive firms marginal revenue is the price. (For monopolies it is different).

## Profit Maximization

An example:

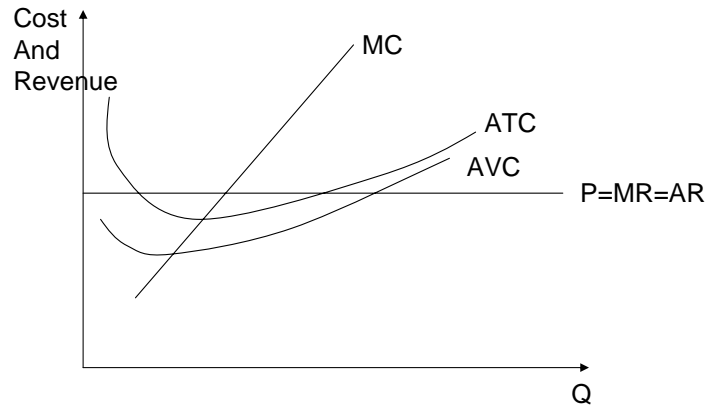
Q	TR	TC	Profit	MR	MC	MR-MC
0	0	3	-3	-	-	-
1	6	5	1	6	2	4
2	12	8	4	6	3	3
3	18	12	6	6	4	2
4	24	17	7	6	5	1
5	30	23	7	6	6	0
6	36	30	6	6	7	-1
7	42	38	4	6	8	-2
8	48	47	1	6	9	-3

Two ways to find the profit-maximizing quantity. One is to look at profit (total revenue minus total cost) and see where it is highest. Another is to see where marginal revenue minus marginal cost is zero.

As long as marginal revenue from a unit of milk exceeds marginal cost of producing that unit, it should be produced.

Profit is maximized at somewhere between 4 and 5 gallons of milk. At this quantity the marginal revenue minus marginal cost is zero.

The firm's MC, ATC, AR and MR curves look like this:



This graph shows at what quantity the firm should produce: Where marginal cost equals marginal revenue. At this quantity profit is maximized.

At any quantity below that, marginal cost is lower than marginal revenue, and an additional unit should be produced.

At any quantity above that, marginal cost is higher than marginal revenue. By decreasing production by one unit, firm would increase profit.

The firm will adjust production until marginal revenue equals marginal cost.

This applies to any profit-maximizing firm, not just competitive firms.

Firm's short-run decision to shut down

Decision to temporarily shut down is different from decision to exit the market.

Shutdown means short-run decision not to produce anything during a period of time.

Exit means long-run decision to leave the market.

Firms can't avoid fixed costs in short run but can in long run.

A firm that shuts down temporarily still has to pay its fixed costs. A firm that exits the market does not – pays no costs.

Consider production decision of a farmer.

Cost of land is a fixed cost in short run.

If farmer decides not to produce any crops one season, cannot recover cost of land. Thus cost of land is a sunk cost.

If farmer decides to exit the market, land can be sold and is no longer a sunk cost.

Short run shutdown decision: If firm shuts down, loses all revenue, saves all variable costs, must still pay fixed costs.

Firm shuts down if (maximum possible) revenue is less than variable costs of production.

Shut down if  $TR < VC$ .

This means, shut down if  $TR/Q < VC/Q$ , or if  $P < AVC$ .

If price doesn't equal or exceed average variable cost, the firm is better off not producing anything. It loses money (fixed costs) when stopping production, but would have lost more money if produced something.

Competitive firm's short-run production decision: If the firm produces anything, it produces where marginal cost equals price of the good. If that price is below the average variable cost at that quantity, firm produces nothing.

This gives competitive firm's short-run supply curve: The portion of the marginal cost curve that lies above variable cost, and zero for prices below minimum of average variable cost.