Production Function

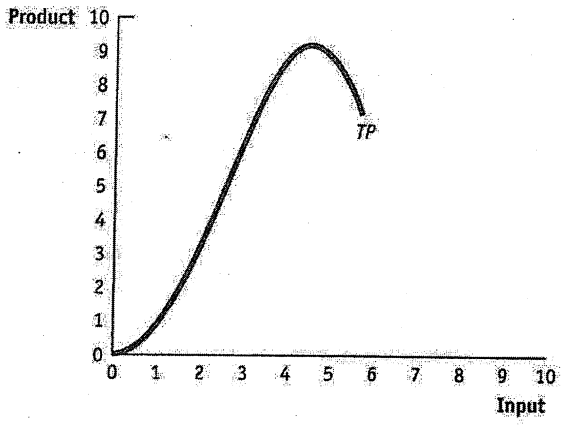
A production function illustrates the way in which fixed and variable inputs are combined to produce output.

A fixed input is an input whose quantity cannot be easily changed for a period of time. Typical fixed inputs are land and capital.

A variable input is an input whose quantity can be easily changed at any time. Typical variable inputs are labor and raw materials.

A production function graph illustrates the level of output (total product) produced using different levels of the variable input. Fixed input(s) are held constant along a production function.

The marginal product of an input is the additional output produced by using one more unit of that input.



The marginal product equals the change in output resulting from a change in a variable input.

$MP_L = \Delta TP/\Delta L$

The marginal product is also the slope of the total product curve.

When more of a variable input (such as labor) is added to a fixed input (such as capital), the marginal product of the variable input eventually declines. This is shown on the graph as a decrease in the slope of the total product curve from left to right. This is referred to as the "principle of diminishing returns" to that input.

The average product of an input is the output produced *per unit* of the input used. Average product equals the total product divided by the units of input used.

$AP_L = TP/L$

The short run is a period of time too short to change the fixed input(s). The long run is a period of time long enough to vary all inputs.

In the long run, firms can increase the level of fixed inputs. An increase in fixed inputs will shift the production function upward.

Average and Marginal Cost Curves

In the short run, there are fixed inputs that create fixed costs. There are also variable inputs that create variable costs.

Total cost of production in the short run is the sum of fixed costs and variable costs.

$TC = VC + FC$

Marginal cost of production is the additional cost of producing the next unit of output.

$MC = \Delta TC / \Delta Q$

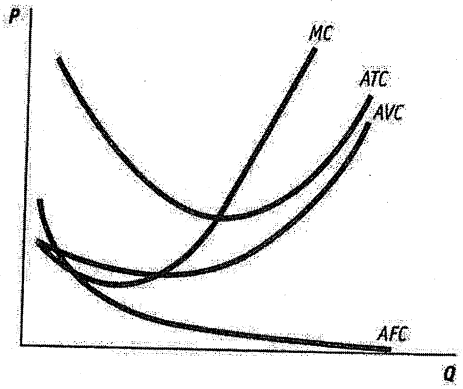
Marginal cost initially declines due to specialization but eventually diminishing returns to production cause marginal cost to increase.

Average, or per unit, costs are found by dividing total costs by the number of units produced.

$ATC = TC/Q$, $AVC = VC/Q$
$AFC = FC/Q$

AFC declines as more output is produced. *FC* is constant and we are dividing by more and more output.

The *ATC* and *AVC* curves have a U-shape.



The *AC* curves have a U-shape because of two effects:

The spreading effect. The larger the output, the greater the quantity over which fixed cost is spread, leading to lower average fixed cost.

The diminishing returns effect. The larger the output, the greater the variable input required to produce additional units, leading to higher average variable cost.

At low levels of output, the spreading effect is very powerful. As output rises, diminishing returns becomes the dominant effect.

The marginal cost curve intersects both *ATC* and *AVC*, two U-shaped curves, at their respective minimum points.

MC must cross *ATC* and *AVC* at their minimums because if the cost of the marginal (next) unit of output is below the average, it will pull the average down.

If the cost of the marginal (next) unit of output is above the average, it will pull the average up.

Initially, *ATC* and *AVC* are falling, so *MC* must be below them. When *ATC* and *AVC* increase, *MC* must be above them.