

Product: Total, Marginal, Average, and (Marginal) Revenue

by Sophia



WHAT'S COVERED

This tutorial will cover the different ways of looking at production: overall or total product, marginal product, and average product. We will discuss how a firm uses these to determine how much labor they need to hire and how much capital they need to purchase.

Our discussion breaks down as follows:

1. Total Product
2. Marginal Product
3. Average Product
4. Relationship Between Marginal Product and Average Product
5. Diminishing Marginal Product
6. Marginal Revenue Product

1. Total Product

All firms must decide how to produce their good or service.

Most firms use a combination of workers and machines, so they need to figure out the combination of labor (how many workers to hire) and capital (how many machines to purchase) that will minimize their costs and optimize their output.

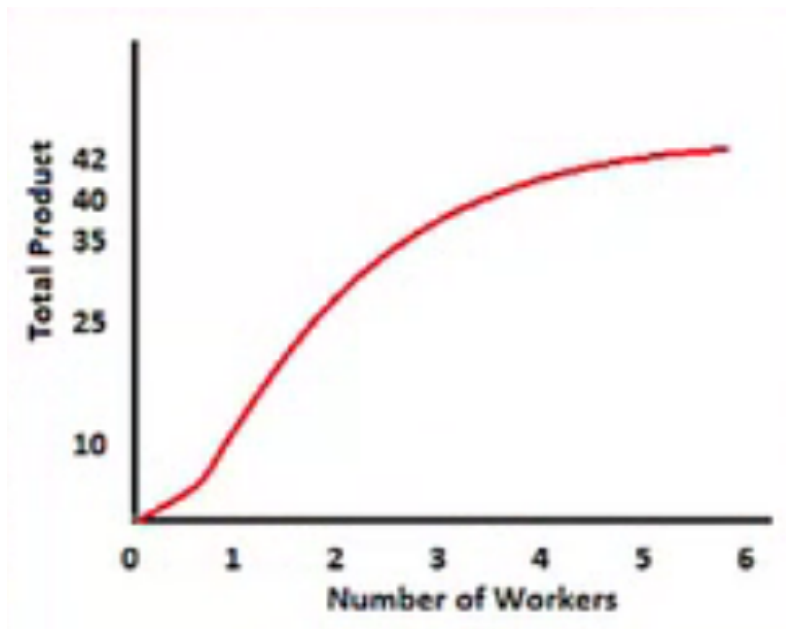
Total product is the quantity of goods and services produced overall.

This chart details labor, not capital, showing the number of employees. You can see the relationship between the number of employees that a firm hires and the overall production that corresponds to the number of employees.

Number of Employees	Total Product
0	0
1	10
2	25
3	35
4	40
5	42
6	42

Now, it makes sense that as the firm hires more employees, they are able to produce more.

If we were to graph it, with total product on the y-axis and the number of workers on the x-axis, the curve would look something like this.



The reason why it is shaped this way has something to do with marginal product, which we will cover next.



TERM TO KNOW

Total Product

Quantity of goods/services produced

2. Marginal Product

Marginal product is the output produced when we add one additional unit of input.



Remember, the word marginal means additional.

Here we've just added a marginal product column to the same chart shown before.

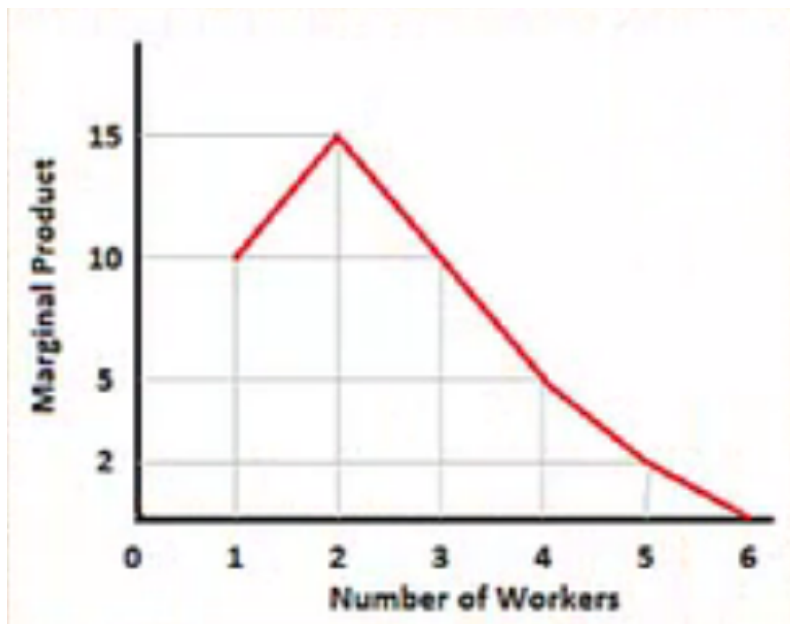
Number of Employees	Total Product	Marginal Product
0	0	--
1	10	10
2	25	15
3	35	10
4	40	5
5	42	2
6	42	0

As you can see, when we go from 0 to 1 employees, we generate 10. The second employee generates an additional 15, raising it from 10 up to 25. The third employee generates an additional 10, and so on.

You will notice that the sixth employee actually doesn't contribute anything additionally to the firm's overall production, which we will discuss shortly.

If we graph marginal product on the y-axis, with number of workers on the x-axis, the curve initially goes up, then begins to diminish.

Notice that at worker number 6, it hits 0.



This is the **marginal product of labor**, or the MPL, since we are looking at how much each employee adds to total production. It is the additional output generated by adding one more unit of labor.

Now, if we had the number of machines in the column instead of number of employees, it would show us the **marginal product of capital**, abbreviated MPK, which is the additional output generated by adding one more unit of capital.



TERMS TO KNOW

Marginal Product

The output produced when we add one additional unit of input

Marginal Product of Labor

Additional output generated by adding one more unit of labor

Marginal Product of Capital

Additional output generated by adding one more unit of capital

3. Average Product

Average product is total output divided by quantity of inputs. We can refer to it as the average product of labor or average product of capital, in the same way that we had the marginal of both of these things.



FORMULA TO KNOW

Average Product

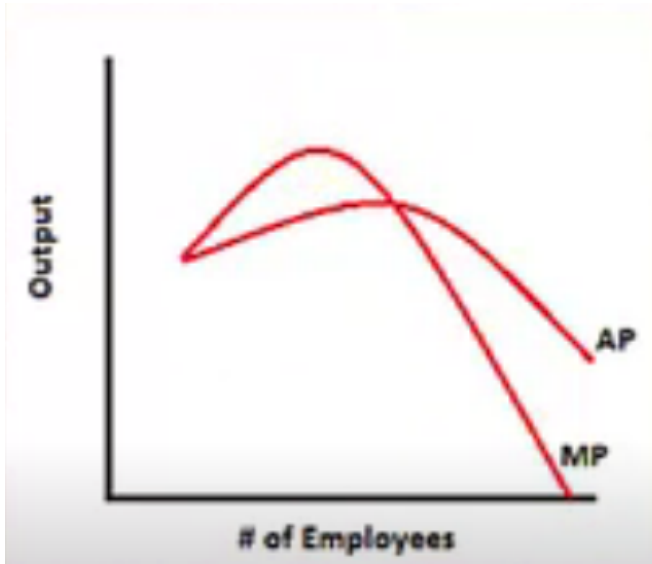
$$AP = \text{Total Output} \div \text{Quantity of Inputs}$$

Again, keeping with the number of employees, we are adding an average product column here, calculated by taking the total product and dividing by the quantity, or number of employees.

Number of Employees	Total Product	Marginal Product	Average Product
0	0	--	--
1	10	10	10.0
2	25	15	12.5
3	35	10	11.7
4	40	5	10.0
5	42	2	8.4
6	42	0	7.0

This tells us, for example, that if we have three employees, on average each employee is producing 11.7 units.

If we graph it, you can see that the average product curve goes up at first and then falls, just as marginal product initially went up and fell.



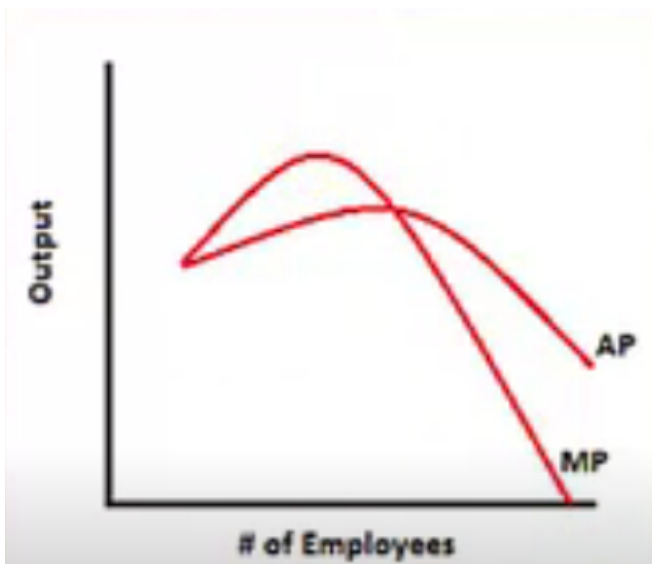
TERM TO KNOW

Average Product

Total output divided by quantity of inputs. Should be the average product of labor, or average product of capital.

4. Relationship Between Marginal Product and Average Product

Let's discuss these two curves and how they are related to one another.



Notice the relationship between these two curves:

- Where the marginal lies above the average, it pulls the average up.



HINT

Using a sports analogy, suppose a quarterback has an average of two touchdown passes per game, represented by the average product curve. The marginal curve represents his next game, because remember, marginal means additional. If, in the next game, he has a stellar game and has five touchdown passes, it will naturally bring up his average of two.

Similarly, with marginal and average product of labor, adding another worker will add more than the average to output.

As soon as that quarterback has a bad game--such as zero touchdown passes--it will pull his average down, where the marginal lies below the average.

- Where the marginal lies below the average, it pulls the average down.

In other words, adding another worker will add less than the average to output.



HINT

Now, this doesn't mean necessarily that overall output will be brought down; it simply means that they will add less than the average to output.

5. Diminishing Marginal Product

This brings us to a concept called **diminishing marginal product**, which states that the marginal product of capital or labor will begin to fall at some point, holding everything else constant.

Number of Employees	Total Product	Marginal Product	Average Product
0	0	--	--
1	10	10	10.0
2	25	15	12.5
3	35	10	11.7
4	40	5	10.0
5	42	2	8.4
6	42	0	7.0

Diminishing
Marginal
Product
sets in here



Notice how total product is increasing except when we hire the sixth employee. However, it is increasing at different rates, which is what marginal product measures. It measures the rate at which total product is

changing.

Look at what the second employee adds to the firm. He actually adds more than the first worker. Why would that be?

Well, if you think about it, specialization provides an explanation. With two people, you can get so much more done than with just one person.

Remember, though, in the short run, there is a fixed input, so there is a fixed amount for these workers to work with.

At some point, specialization runs out. Hiring more workers will help you produce more, but the next worker won't be as good as the one before, because there is simply not enough for them all to do or for them all to have specialized, devoted tasks.

Look at the arrow pointing to where diminishing marginal product sets in, at the third worker.

Total product is still increasing. Hiring another worker or investing in a new machine for capital is still helping to increase production, just not as much as the one before, which is what diminishing marginal product is all about.

Note that we would never want to hire a seventh employee, because more than likely, that would be the point where they would actually bring down production.

That is the point at which the workers are getting in each other's way and it is actually less productive to have another employee.



TERM TO KNOW

Diminishing Marginal Product

The marginal product of capital/labor will begin to fall at some point, holding all else constant

6. Marginal Revenue Product

So, how will a firm use all of this information?

We need to link all of this to the revenue they can generate and the cost of the inputs:

- The price of their product
- The cost of labor or capital

This is where the marginal revenue product comes in.

The **marginal revenue product** is the additional sales revenue received from employing one more unit of labor or capital.

Looking at the chart below, marginal revenue product is simply taking the marginal product and multiplying by the price of the product--which is \$10, in this example.



FORMULA TO KNOW

Marginal Revenue Product

$$MRP = \text{Marginal Product} \times \text{Marginal Revenue (Price of Good)}$$

Number of Employees	Total Product	Marginal Product	Marginal Revenue Product
0	0	--	--
1	10	10	\$100
2	25	15	\$150
3	35	10	\$100
4	40	5	\$50
5	42	2	\$20
6	42	0	\$0



THINK ABOUT IT

Suppose it will cost \$80 to hire a worker. Should you hire a third worker? Yes, you should, because that third worker will generate \$100 of extra revenue for the firm, while only costing you \$80. Therefore, it will add \$20 to profit.

However, should you hire a fourth worker? Absolutely not. The cost would be an additional \$80 and that fourth worker will only generate another \$50 of revenue for the firm. In this case, your profit would fall by \$30.

This is how a firm uses marginal revenue product to make decisions.



TERM TO KNOW

Marginal Revenue Product

Additional sales revenue received from employing another unit of labor/capital



SUMMARY

Today we learned about the different ways of looking at production: **total product**, **marginal product**, and **average product**. We learned about the **relationship between marginal product and average product** and how a firm uses these to determine how much labor to hire and capital to purchase,

factoring in the **diminishing marginal product** which states that the marginal product of capital or labor will begin to fall at some point, holding all else constant. We also learned that a firm uses the marginal product of labor and the marginal product of capital to determine the **marginal revenue product** that each is contributing.

Source: Adapted from Sophia instructor Kate Eskra.



TERMS TO KNOW

Average Product

Total output divided by quantity of inputs. Should be the average product of labor, or average product of capital.

Diminishing Marginal Product

The marginal product of capital/labor will begin to fall at some point, holding all else constant.

Marginal Product

The output produced when we add one additional unit of input.

Marginal Product of Capital

Additional output generated by adding one more unit of capital.

Marginal Product of Labor

Additional output generated by adding one more unit of labor.

Marginal Revenue Product

Additional sales revenue received from employing another unit of labor/capital.

Total Product

Quantity of goods/services produced.



FORMULAS TO KNOW

Average Product

$$AP = \text{Total Output} \div \text{Quantity of Inputs}$$

Marginal Revenue Product

$$MRP = \text{Marginal Product} \times \text{Marginal Revenue (Price of Good)}$$