Intermediate Microeconomics. Lecture 12

Producer theory

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Contents

Simplifying Assumptions about Firms' Production Behavior

- The firm produces a single good
- The firm has already chosen which product to produce
- For whatever quantity it makes, the firm's goal is to minimize the cost of producing it
- The firm uses only two inputs to make its product: capital and labor
- In the short run, a firm can choose to employ as much or as little labor as it wants, but it cannot rapidly change how much capital it uses

Simplifying Assumptions about Firms' Production Behavior

- In the long run, the firm can freely choose the amounts of both labor and the capital it employs
- The more inputs the firm uses, the more output it makes
- A firm's production exhibits diminishing marginal returns to labor and capital
- The firm can buy as many capital or labor inputs as it wants at fixed market prices

Contents

Production Functions

A production function is a mathematical relationship that describes how much output can be made from different combinations of inputs

$$Q = f(K, L)$$

Production Functions

The type of production function in which capital and labor are each raised to a power and then multiplied together is known as a Cobb–Douglas production function

$$Q = K^{\alpha} L^{1-\alpha}$$

Contents

Production in the Short Run

- While the capital stock is fixed in the short run, the firm can choose how much labor to hire to minimize its cost of making the output quantity
- Consider the following Cobb–Douglas production function

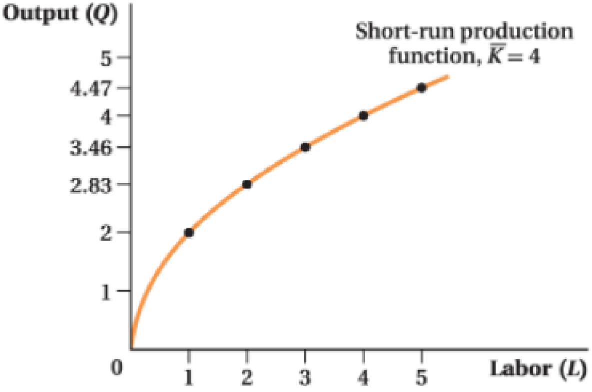
$$Q = K^{0.5} L^{0.5}$$

- In this example capital is fixed at 4 units (in the short run): $\bar{K} = 4$

$$Q = 4^{0.5} L^{0.5} = 2L^{0.5}$$

- Next figure plots the short-run production function

Production in the Short Run



Goolsbee et al., *Microeconomics*, 3e, © 2020 Worth Publishers

Figure: Short-Run Production Function

Marginal Product

- The additional output that a firm can produce by using an additional unit of an input (holding use of the other input constant) is called the marginal product
- The marginal product of labor (MP_L) is the change in quantity (ΔQ) resulting from a 1-unit change in labor (ΔL)

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

$$MP_L = \frac{\partial Q}{\partial L}$$

$$MP_L = \frac{\partial (2L^{0.5})}{\partial L} = 0.5(2L^{-0.5}) = L^{-0.5} = \frac{1}{L^{0.5}}$$

Marginal Product

- The diminishing marginal product of labor is the reduction in the incremental output obtained from adding more and more labor
- Keep in mind, however, that diminishing marginal returns do not have to occur all the time; they just need to occur eventually
- A production function could have increasing marginal returns at low levels of labor before running into the problem of diminishing marginal product

Marginal Product

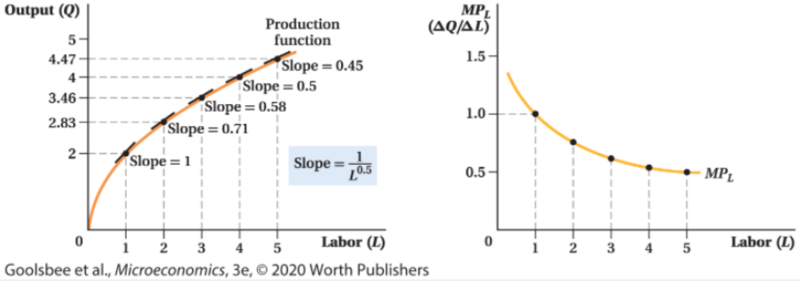


Figure: Deriving the Marginal Product of Labor

Average Product

- Average product is the total quantity of output divided by the number of units of input used to produce it
- The average product of labor (AP_L), for example, is the quantity produced, Q, divided by the amount of labor L used to produce it

$$AP_L = \frac{Q}{L}$$

Example

The short-run production function for a firm that produces pizzas is

$$Q = f(\bar{K}, L) = 15\bar{K}^{0.25}L^{0.75}$$

where Q is the number of pizzas produced per hour, $\bar{K}$ is the number of ovens (which is fixed at 3 in the short run), and L is the number of workers employed

- Write an equation for the short-run production function for the firm showing output as a function of labor

$$Q = 15(3)^{0.25}L^{0.75} = 15(1.316)L^{0.75} \Rightarrow \boxed{Q = 19.74L^{0.75}}$$

Example

- Calculate the total output produced per hour for L = 0, 1, 2, 3, 4, and 5.
- Calculate the MPL. Is MPL diminishing?
- Calculate the APL

$$MP_L = \frac{\partial Q}{\partial L}$$

$$MP_L = \frac{\partial 19.74L^{0.75}}{\partial L} = 19.74(0.75)L^{-0.25} = 14.805L^{-0.25}$$

$$\boxed{MP_L = 14.805\frac{1}{L^{0.25}}}$$

Contents

The Long Run

In the long run, firms can change not only their labor inputs but also their capital. This difference gives them two important benefits

- First, in the long run, a firm might be able to lessen the sting of diminishing marginal products
- The second benefit of being able to adjust capital in the long run is that producers often have some ability to substitute capital for labor or vice versa

The Long-Run Production Function

The long-run production function is the same one we saw before, but rather than having a fixed level of $\bar{K}$ and choosing L, now the firm can choose the levels of both inputs

$$Q = f(K, L)$$

For example, we could have the following long run production function

$$Q = K^{0.5}L^{0.5}$$

The Long-Run Production Function

Using this production function, $Q = K^{0.5}L^{0.5}$, we can compute the marginal product of each factor

$$MP_L = \frac{\partial f(K,L)}{\partial L} = 0.5K^{0.5}L^{-0.5}$$

$$MP_K = \frac{\partial f(K,L)}{\partial K} = 0.5K^{-0.5}L^{0.5}$$