

## 3 Production and Costs

### 3.1 Lecture 5: Production

#### 3.1.1 Production function

- The goal of firms is to maximize profits by minimizing costs, given technological constraints.
- **Production functions** describe what is technologically feasible for firms to produce. Firms convert inputs (or factors of production) into outputs through a production process. Here outputs are the goods and services produced by the firm, and inputs are **capital** and **labor**.

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

where  $q$  is output,  $L$  is labor, and  $K$  is capital.

- In the **short run**, at least one input is fixed. In the **long run**, all inputs are variables.

#### 3.1.2 Short run production

- Recall that in the short run, at least one input is fixed. Suppose we have fixed capital and variable labor. **Marginal product of labor** is the change in the total output resulting from using an extra unit of labor, holding other inputs constant.

$$MP_L = \frac{\delta q}{\delta L}$$

Generally, we assume **diminishing marginal products**: the next worker increases output more than the previous one.

- **Marginal product of capital** is the additional output gained from one extra unit of capital, holding the other inputs constant.

$$MP_K = \frac{\delta q}{\delta K}$$

#### 3.1.3 Long run production

- **Isoquants** are curves showing all  $(L, K)$  combinations producing the same output. The shape of isoquants is determined by the degree of substitutability between inputs.
- The slope of isoquant is the **marginal rate of technical substitution (MRTS)**.  $MRTS$  varies along the isoquant.  $MRTS$  falls as labor increases. Isoquants exhibit diminishing marginal rates of technical substitution.

$$MRTS = \frac{\delta K}{\delta L} = -\frac{MP_L}{MP_K}$$

### 3.1.4 Returns to scale

There are three cases when you increase all inputs proportionally:

- **Constant returns to scale:** input increases proportionally, and output increases proportionally. For example,  $f(2L, 2K) = 2f(L, K)$ .
- **Increasing returns to scale:** input increases proportionally, and output increases more than proportionally. For example,  $f(2L, 2K) > 2f(L, K)$ .
- **Decreasing returns to scale:** input increases proportionally, and output increases less than proportionally. For example,  $f(2L, 2K) < 2f(L, K)$ .

### 3.1.5 TO KNOW – Conceptual Understanding

- Understand the inputs and outputs of production function
- Identify the differences between short run and long run production
- Identify different cases of returns to scale: constant, increasing, decreasing

### 3.1.6 TO KNOW – Graphical and Math Understanding

- Calculate the marginal product of labor, marginal product of capital
- Graph isoquants, and see how its slope is the marginal rate of technical substitution. Calculate  $MRTS$  given production function

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