Week #6 Notes – Explicit Cost ~ ATC, AVC, and AFC

1. **Production:** is the process of using the services of labor and equipment together with other inputs to make goods and services available.

2. **Production Function:** describes the relationship between any given combination of inputs and the maximum attainable output from those inputs given current technology.

    a. We will assume that there are only two inputs, labor (L) and capital (K)
    b. $Q = f(L, K)$ ← Production Function

3. **Short Run vs. Long Run:**

    a. **Short Run:** is a period of production during which some inputs cannot be varied.
    b. **Long Run:** is a period of production during which all inputs can vary. In the long run there are no fixed inputs.
    c. **Variable Input:** is one whose quantity can be changed over the short run.
    d. **Fixed Input:** is one whose quantity cannot be changed over the short run.
    e. We will assume labor is a variable input and capital is a fixed input in the short run.

4. **Total Product:** A total product curve describes how output varies in the short run as more of any one input is used together with fixed amounts of other inputs under current technology. ➔ The notation we use is *TP*
    a. The total product of labor is the amount of output (Q) produced over a given period by a certain amount of labor (L) employed together with fixed inputs (K).
        ➔ The notation we use for total product of labor is TP_L

5. **Marginal Product:** The marginal product of an input is the increase in output from one more unit of that input when the quantity of all other inputs is unchanged. ➔ The notation we use is *MP*
    a. The marginal product of labor is the extra output produced with one more unit of labor. ➔ The notation we use for marginal product of labor is MP_L
    b. Notice that marginal product increases at first and then decreases. Also, when marginal product is decreasing, the rate of increase in total product is declining, which is because the marginal product of labor is the slope of the total product curve. ➔
    $$MP_L = \frac{\Delta TP_L}{\Delta L} = \frac{\Delta Q}{\Delta L}$$
    c. When the marginal product of labor is zero, total product is at its maximum value.
    d. When the marginal product is negative, additional workers decrease the total product.

6. **Average Product:** The average product of an input is the total output produced over a given period divided by the number of units of that input used. ➔ The notation we use is *AP*.
    a. The average product of labor is output per unit labor. ➔ $AP_L = \frac{TP_L}{L} = \frac{Q}{L}$
    b. The average product of labor is a measure of productivity.
    c. The average product of labor increases at first, reaches a maximum, and then decreases. So, the labor productivity increases at first and then decreases. Although AP_L becomes smaller and smaller it never reaches to zero.

7. **The Relationship between Average and Marginal Products of Labor:**
   a. When $MP_L > AP_L$ the average product of labor will rise.
   b. When $MP_L < AP_L$ the average product of labor will decline.
   c. When $MP_L = AP_L$ the average product of labor will be at the maximum.

8. **The Law of Diminishing Marginal Returns:** states that the extra production obtained from increases in a variable input will eventually decrease as more of the variable input is used together with the fixed inputs.
   a. The point of diminishing returns corresponds to the level that the marginal product begins to decline.
   b. Also implies that the average product of a variable input will eventually decline as more of that input is used together with fixed inputs.

   Law of diminishing marginal returns ➔ decline in MP_L

   Decline in MP_L eventually causes ➔ decline in AP_L

   ➔ See the exercise 7.1 in the worksheet.
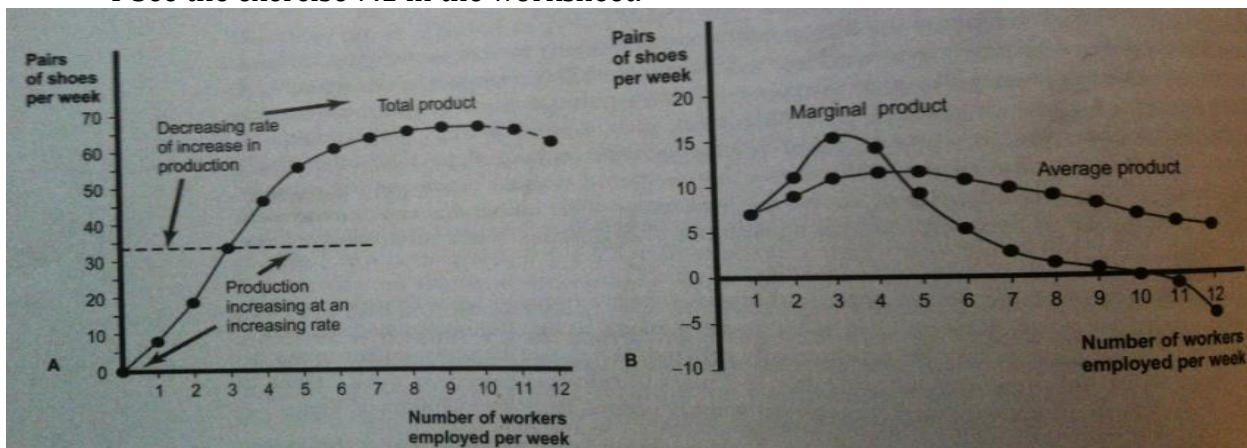
9. **Short-run Cost Curves:** In the short-run costs are divided into two categories.
   a. **Fixed Cost (FC):** The cost of fixed inputs. Fixed costs do not vary with output and are sometimes called overhead costs. These are costs that must be incurred in the short run even if the firm does not produce anything. There is no fixed cost in long-run.
   b. **Variable Costs (VC):** The cost of variable input. Variable cost depends on the number of units of output produced.

10. **Cost Function:** gives the minimum possible cost of producing a given level of output.

    a. Please see the additional lecture notes to derive the variable cost curve from the total product curve.

    b. **Total Cost (TC):** is the sum of fixed cost and variable cost ➔ $TC = TVC + TFC$

    c. **Average Total Cost (ATC):** is the total cost divided by the number of units of output. It's also called *average total cost*. Managers often refer to average cost as their *unit cost*.

    ➔ $ATC = \dfrac{TC}{Q}$

d. **Average Variable Cost (AVC):** is the variable cost divided by the number of units of output.

➔ $AVC = \dfrac{TVC}{Q}$

    i. **Derivation of Shape of Average Variable Cost Curve:**

      ⇨ Assume that the labor is the only variable input.

      ⇨ $AVC = \dfrac{TVC}{Q}$ ➔ $AVC = \dfrac{wL}{Q}$ ➔ $AVC = \dfrac{w}{AP}$

      where $VC = wl$ *and* $AP = \dfrac{Q}{L}$

      ⇨ We know that the shape of AP is "inverted U", so the average variable cost curve is **U-shaped**.

      ⇨ Similarly, the short-run average cost curves are **U-shaped**.

e. **Average Fixed Cost (AFC):** is the fixed cost divided by the number of units of output.

➔ $AFC = \dfrac{TFC}{Q}$

    i. Note that average fixed cost gets smaller and smaller as output increases ➔ implies the difference between average cost and average variable cost decreases as output increases.

f. $TC = TVC + TFC$ ➔ $\dfrac{TC}{Q} = \dfrac{TVC}{Q} + \dfrac{TFC}{Q}$ ➔ $ATC = AVC + AFC$

g. **Marginal Cost (MC):** is the extra cost of producing one more unit of output.

➔ $MC = \dfrac{\Delta TC}{\Delta Q}$

    i. Because the fixed cost does not change as output changes, fixed cost does not influence marginal cost. Marginal cost influenced only by variable cost.

      ⇨ $MC = \dfrac{\Delta TC}{\Delta Q} = \dfrac{\Delta(TVC + TFC)}{\Delta Q} = \dfrac{\Delta TVC}{\Delta Q}$

    ii. Note that the marginal cost curve must intersect both the average variable cost curve and the average cost curve at their minimum points.

    iii. When MC curve is below AC (or AVC), AC will decrease. Similarly, when MC is above AC (or AVC), AC will increase.

iv. Marginal cost decreases at first and then increases. The eventually increasing marginal cost of output reflects the law of diminishing marginal returns.

$$\Rightarrow \quad MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta(TVC + TFC)}{\Delta Q} = \frac{\Delta TVC}{\Delta Q} = \frac{\Delta wL}{\Delta Q} = \frac{w\Delta L}{\Delta Q} = \frac{w}{MP_L}$$

where $MP_L = \dfrac{\Delta TP_L}{\Delta L} = \dfrac{\Delta Q}{\Delta L}$ and $\dfrac{\Delta TFC}{\Delta Q} = 0$

$\Rightarrow$ As more of the variable input is hired, the extra output obtained eventually becomes smaller and smaller. This means that it eventually takes more and more of the variable input to produce each extra unit of output which causes marginal cost to increase.

$\Rightarrow$ So, the shape of the marginal cost curve is the reverse the shape of marginal product curve.

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