

Short-Run Production and Costs

Acknowledgement

These slides was originally made by
Prof. Chayun Tantivasadakarn.

However, I, Mr. Pongpalin Yingchoncharoen,
have edited them with diagrams from other sources.

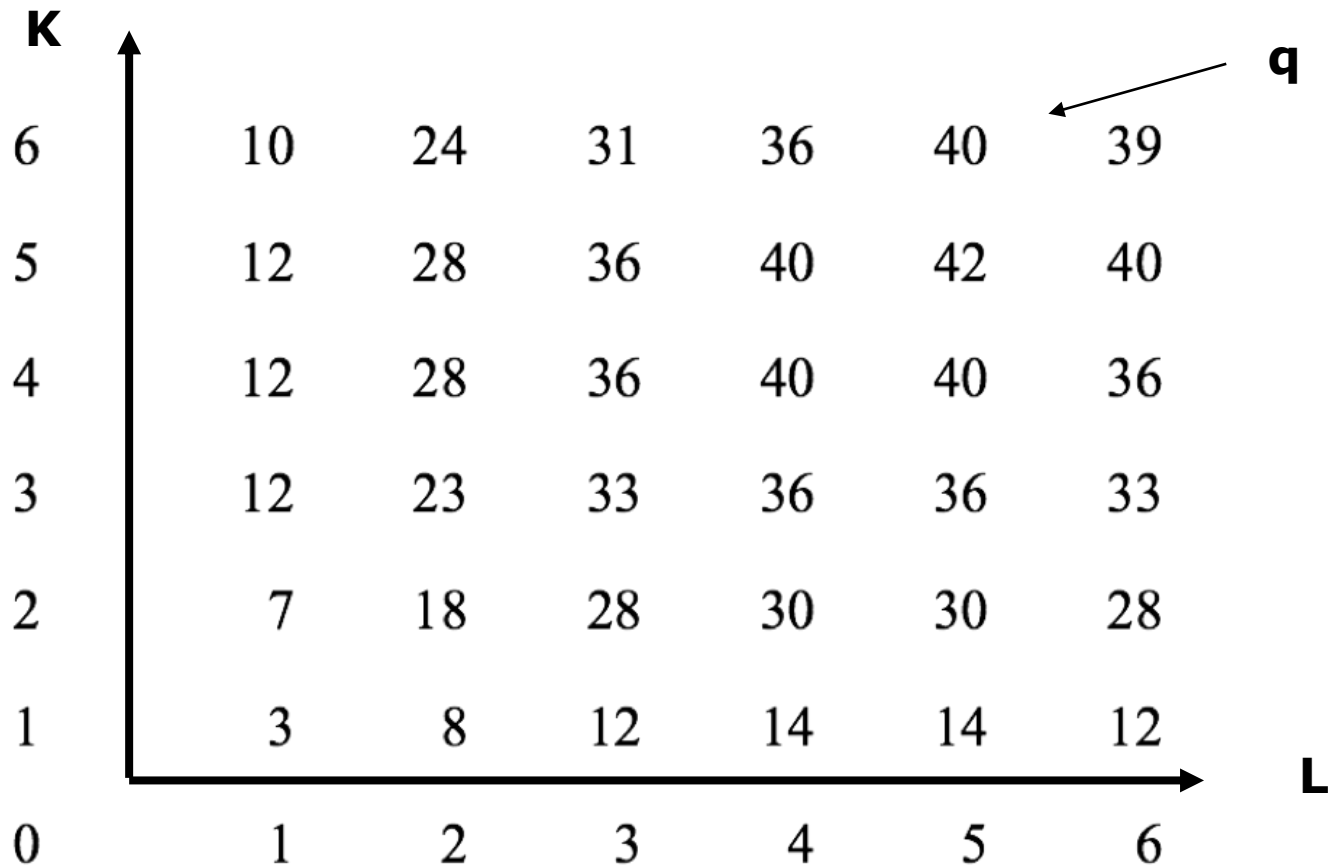
Any mistake is my own.

Production Function

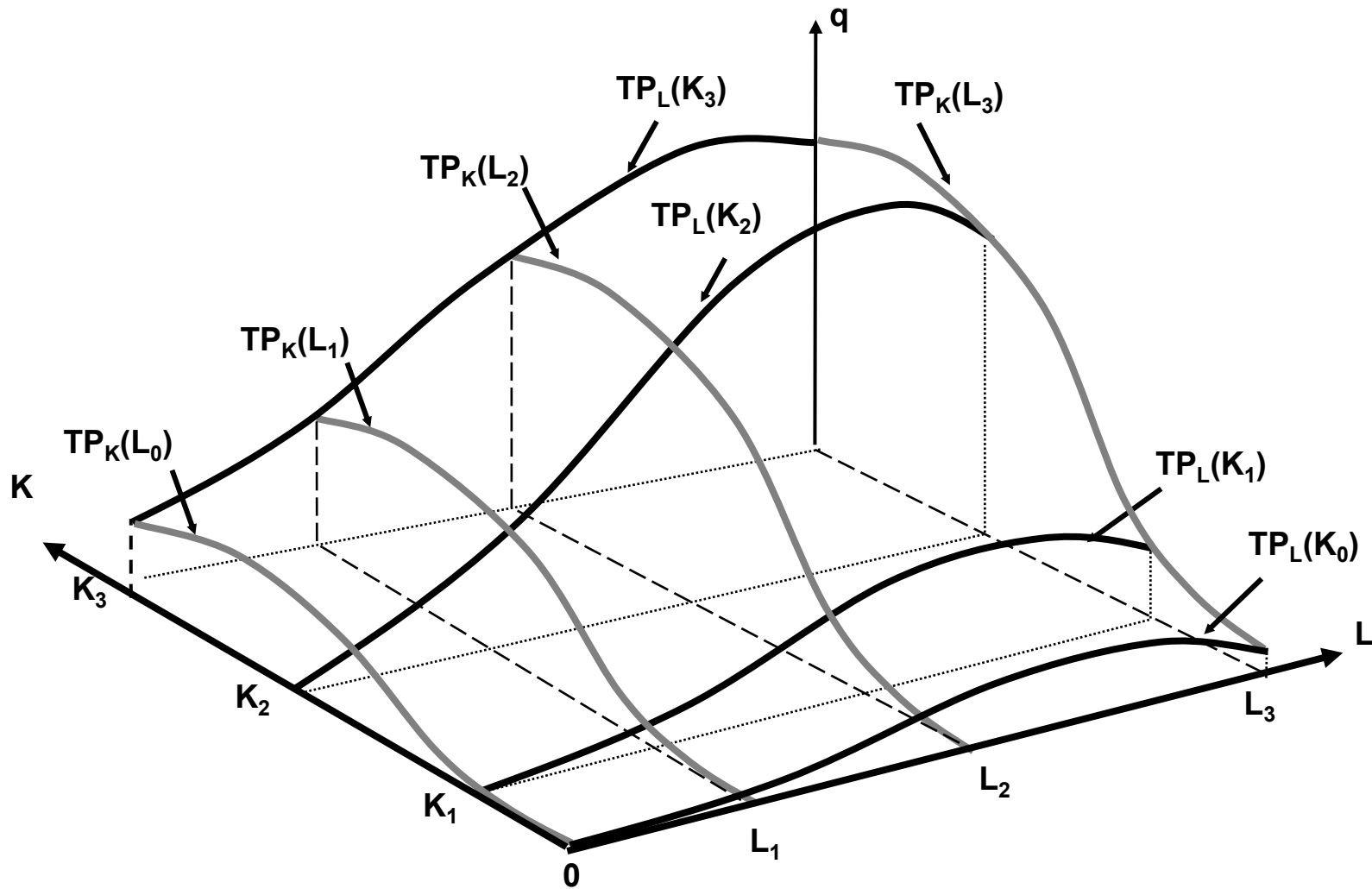
Production Function

- Describes how inputs can be transformed into outputs.
 - Inputs: land, labor, capital & raw materials
 - Outputs: cars, desks, books, etc.
- Indicates the highest output (q) that can be produced from using different combinations of inputs.
- For simplicity, we will consider only labor (L) and capital (K). That is, $q = F(K, L)$.

Representation of a Production Function



Representation of a Production Function



Short Run vs Long Run

Short Run

- Period of time where at least one input is fixed

Long Run

- Period of time where all inputs are variable

Short run and long run are not time-specific.

We will begin looking at the short run where we assume capital is fixed and labor is variable.

S-R Production: One Variable Input

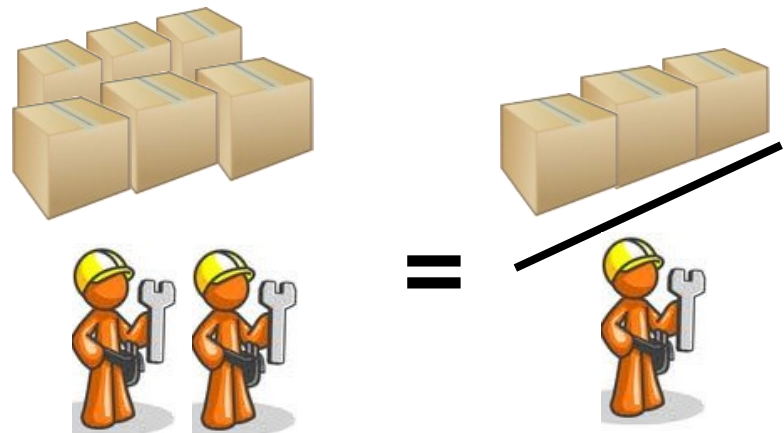
<i>Amount of Labor (L)</i>	<i>Amount of Capital (K)</i>	<i>Total Output (q)</i>	<i>Average Product (q/L)</i>	<i>Marginal Product ($\Delta q/\Delta L$)</i>
0	10	0	—	—
1	10	10	10	10
2	10	30	15	20
3	10	60	20	30
4	10	80	20	20
5	10	95	19	15
6	10	108	18	13
7	10	112	16	4
8	10	112	14	0
9	10	108	12	-4
10	10	100	10	-8

S-R Production: One Variable Input

Average Product of Labor (AP_L)

- Refers to output per unit of labor.
- Measures the productivity of an average worker.

$$AP_L = \frac{\text{Output}}{\text{Labor Input}} = \frac{q}{L}$$

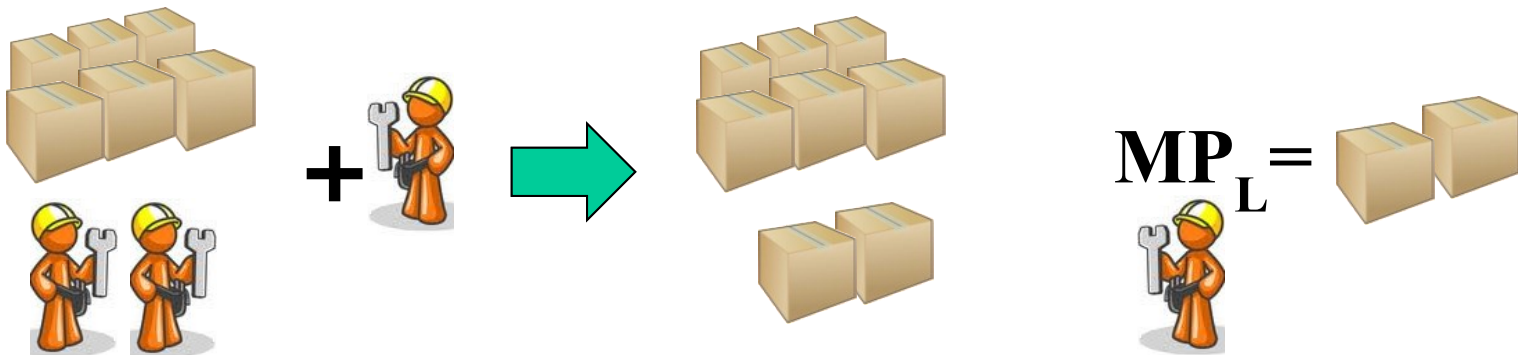


S-R Production: One Variable Input

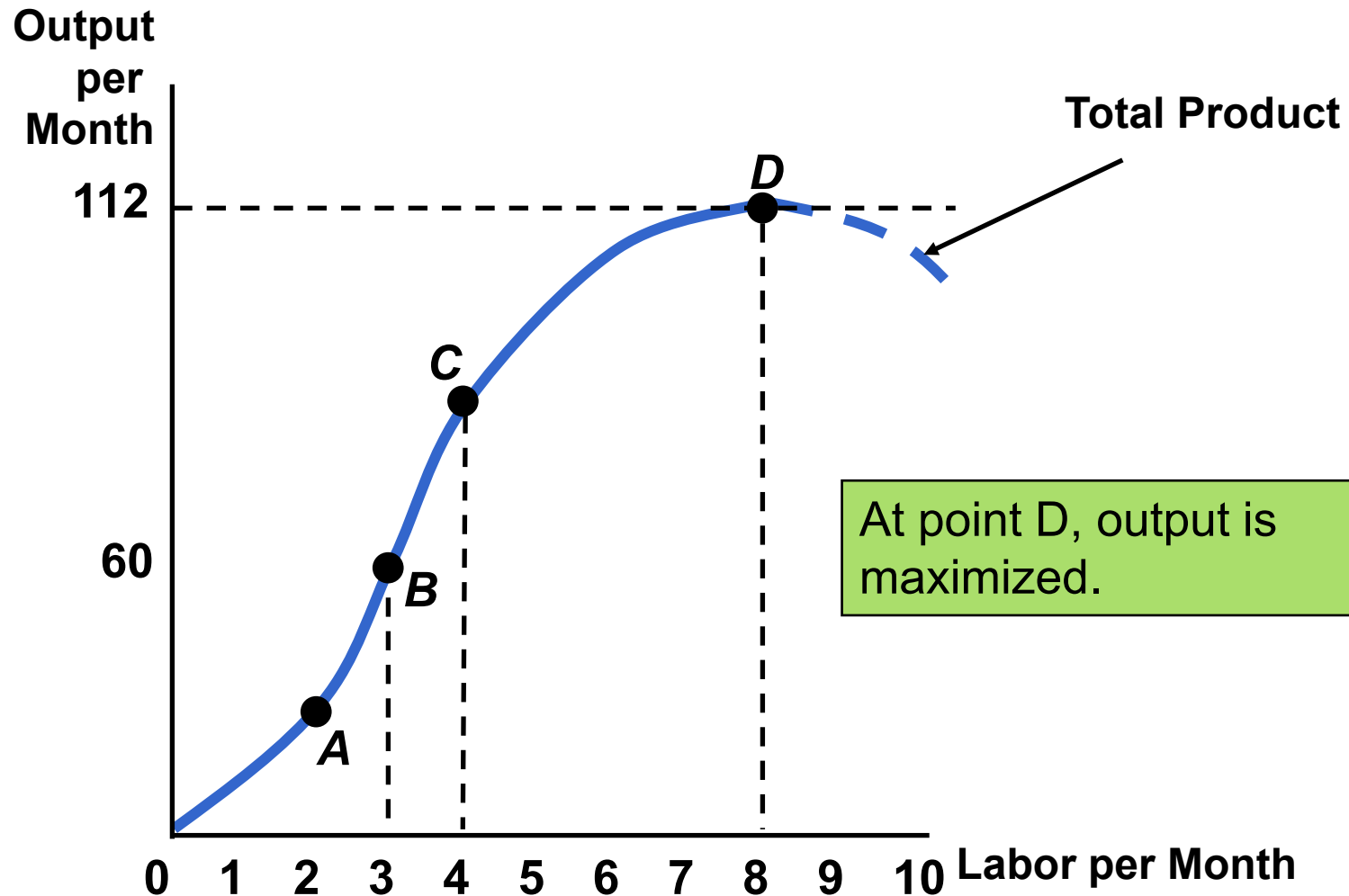
Marginal Product of Labor (MP_L)

- Refers to extra output produced from extra unit of labor.
- Measures the productivity of an extra worker.

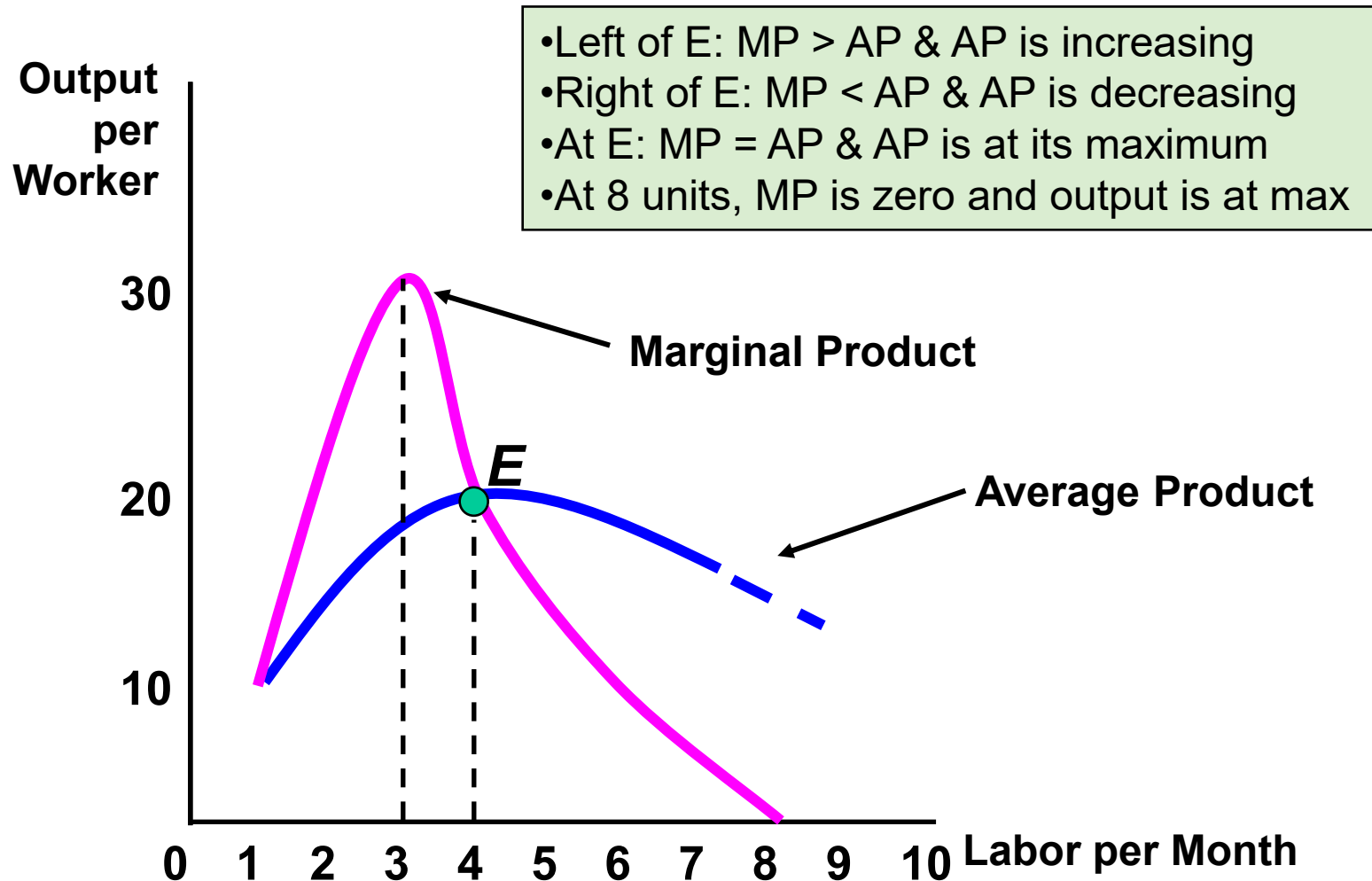
$$MP_L = \frac{\Delta \text{Output}}{\Delta \text{Labor Input}} = \frac{\Delta q}{\Delta L}$$



S-R Production: One Variable Input



S-R Production: One Variable Input



S-R Production: One Variable Input

Observations 1 (about TP)

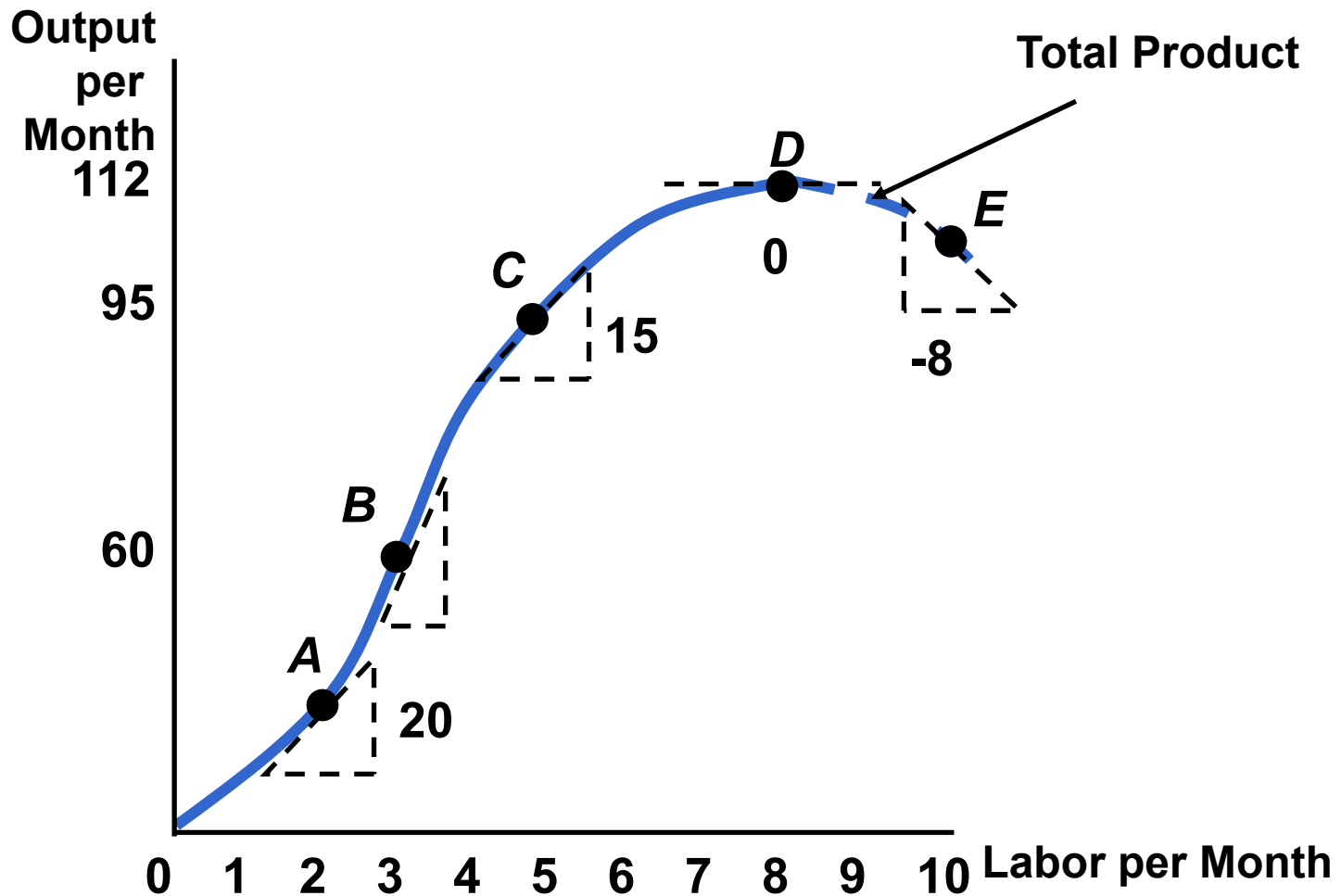
- When labor is zero, output is zero.
- With extra workers, output increases to its maximum when employing 8 units of labor.
- Beyond this point, output declines with extra workers.
 - Increasing labor can make better use of existing capital initially, but after a certain point, more labor is not useful and can be counterproductive.

S-R Production: One Variable Input

Observations 2 (about TP and MP)

- Marginal Product (MP) is the slope of Total Product (TP).
 - When $MP > 0$, an extra worker increases output, so TP slopes upward
 - When $MP = 0$, an extra worker no longer increases output, so TP is flat and is maximized.
 - When $MP < 0$, an extra worker decreases output, so TP slopes downwards.

MP_L = the slope of the line tangent to the TP_L curve

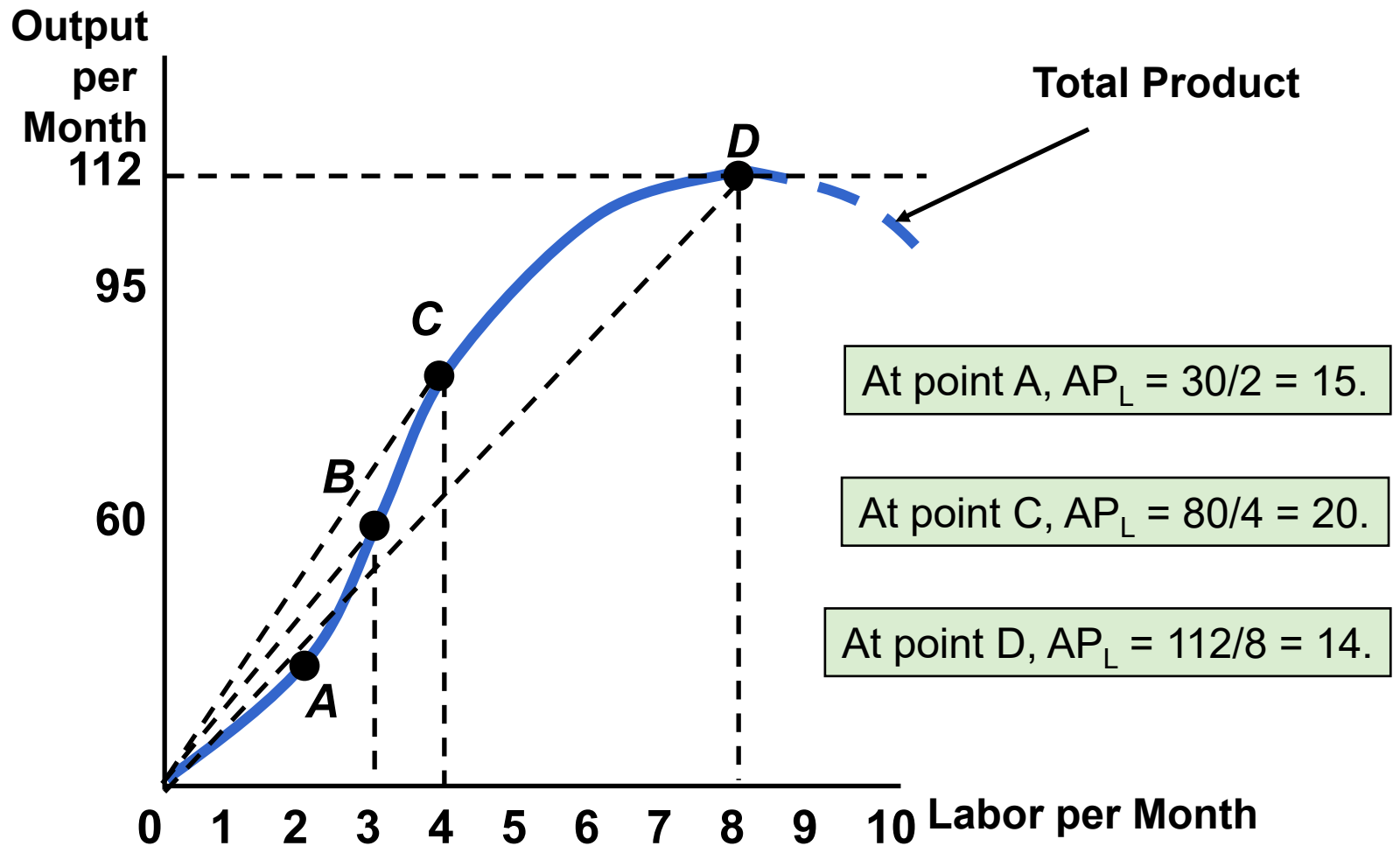


S-R Production: One Variable Input

Observations 3 (about TP and AP)

- The slope of line from origin to any point on the total product curve is the average product.
- At point B, $AP = 60/3 = 20$ which is the same as the slope of line from origin to point B on the total product curve.

AP_L = the slope of the line from the origin to the point on the TP_L curve

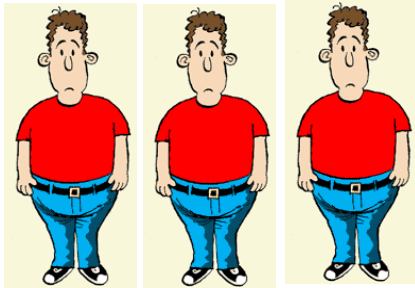


S-R Production: One Variable Input

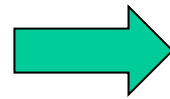
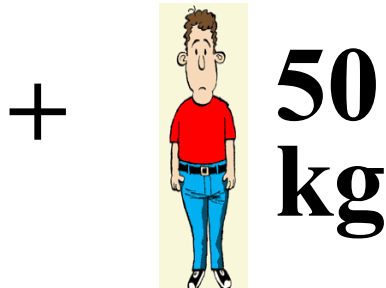
Observations 4 (about MP and AP)

- There is a mathematical relationship between “average value” and “marginal value” of any variable.
 - When $MP > AP$, AP is increasing.
 - When $MP < AP$, AP is decreasing.
 - MP crosses AP at its maximum.
 - When $MP = 0$, TP is at its maximum.

Example: Average and Marginal Values



= 70 kg/person



< 70 kg/person



> 70 kg/person

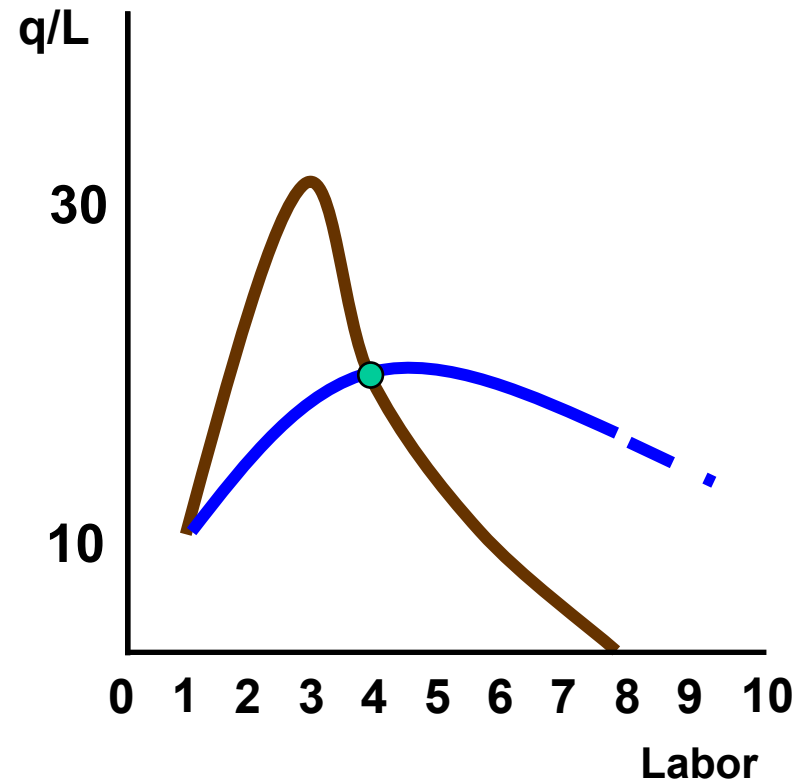
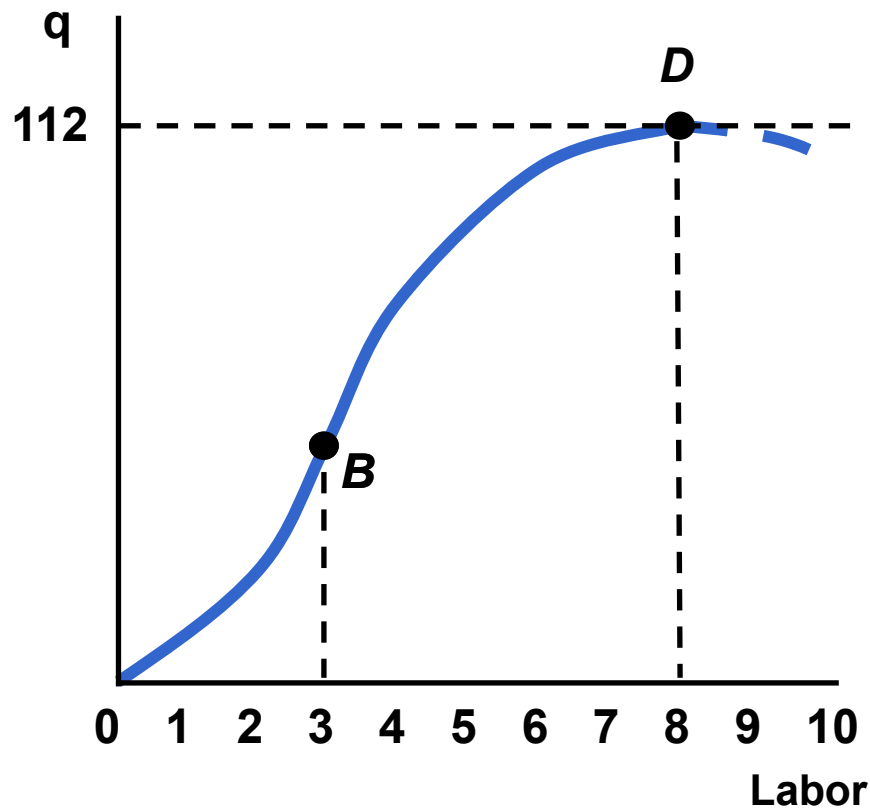
Law of Diminishing Marginal Returns

Law of Diminishing Marginal Returns (LoDR)

- Characterizes the short-run production.
- States that “when more variable inputs (labor) are added to the fixed inputs (capital), the MP of variable inputs eventually diminishes”.
- LoDR arises because of fixed and variable inputs are NOT proportional.

Law of Diminishing Marginal Returns

LoDR starts from point B.
Negative returns starts from point D.



Law of Diminishing Marginal Returns

Observations 5 (about LoDR)

- When the labor is small (before point B), there is division of labor and specialization.
 - Extra workers are more productive (MP increases).
- When the labor is large (after point B), the LoDR sets in.
 - Extra workers are less productive (MP decreases).
- Where the labor is too large (after point D), there are negative returns. Extra workers are counterproductive.

Law of Diminishing Marginal Returns

Observations 5 (about LoDR)

- Diminishing returns eventually leads to negative returns.
- **When more labor is added...**
 - **Diminishing returns** means that MP is becoming smaller. MP may be positive at first and becomes negative later on.
 - **Negative returns** means that MP is negative. This is when output decreases with more labor.

Measuring Costs

Accountants take a retrospective view of a firm's costs, where as economists take a forward-looking view.

- **Accounting Cost** = explicit costs
- **Economic Cost** = explicit and implicit costs
- **Explicit Costs** = costs that involve payment for the actual uses of inputs
- **Implicit Costs** = costs that do not involve payment but account for the foregone uses of inputs (opportunity costs)

Measuring Costs

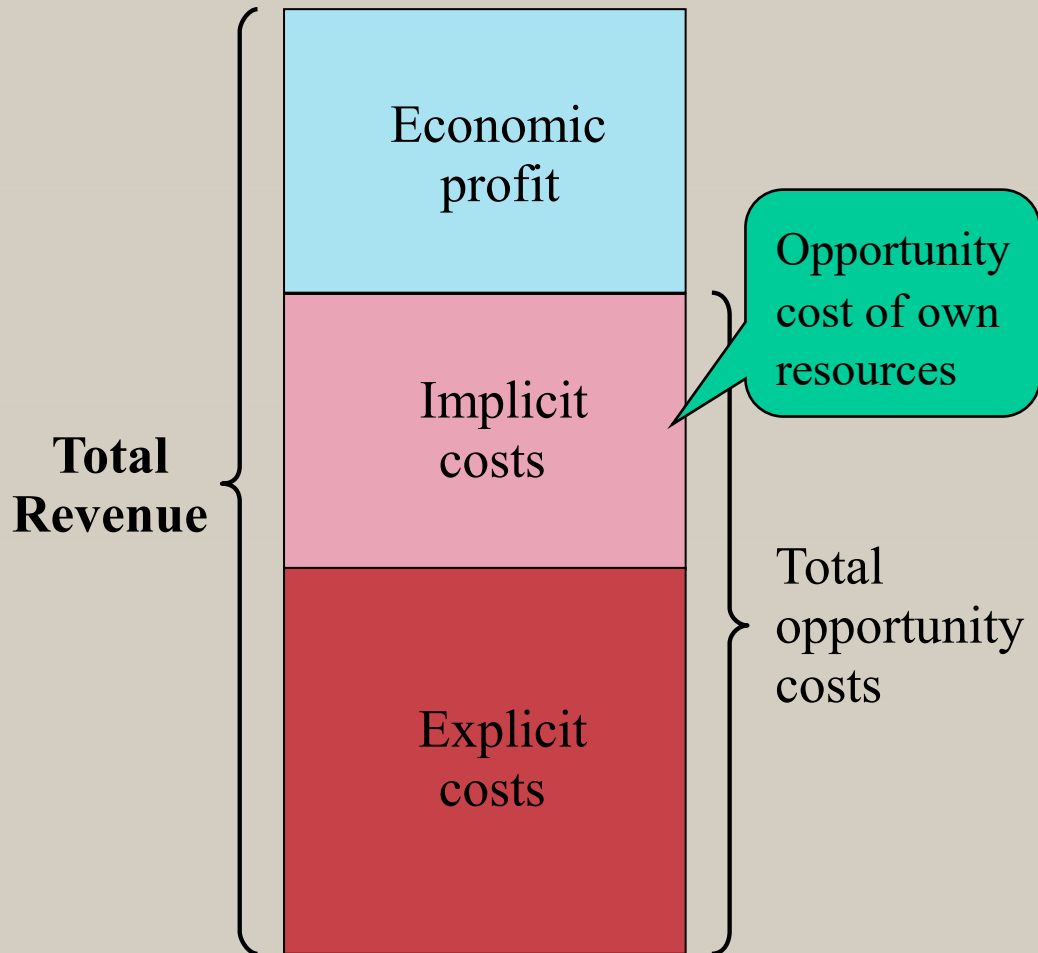


Example of Implicit Costs

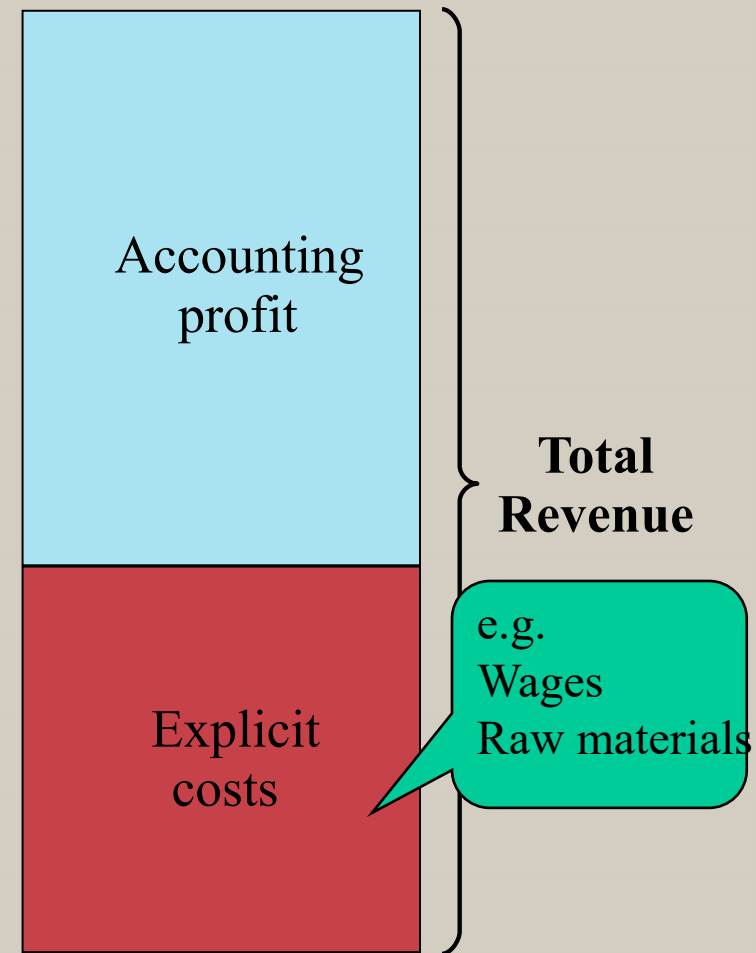
- A firm owns its own building and pays no rent for office space. Does this mean the cost of office space is zero?
- The building could have been rented instead. Foregone rent is the opportunity cost of using the building for production and is included in economic costs of doing business.

Economics versus Accountancy

How an Economist Views a Firm



How an Accountant Views a Firm





Accounting Versus Economic Profit

Item	Accounting Profit	Economic Profit
Total Revenue	\$500,000	\$500,000
Less Explicit costs:		
Wages & salaries	\$400,000	\$400,000
Materials	\$50,000	\$50,000
Interest paid	\$10,000	\$10,000
Other payments	\$10,000	\$10,000
Less implicit costs:		
Foregone salary	0	50,000
Foregone rent	0	10,000
Foregone interest	0	5,000
Equals profit	\$30,000	-\$35,000



Accounting Versus Economic Profit

Item	Accounting Profit	Economic Profit
Total Revenue	\$535,000	\$535,000
Less Explicit costs:		
Wages & salaries	\$400,000	\$400,000
Materials	\$50,000	\$50,000
Interest paid	\$10,000	\$10,000
Other payments	\$10,000	\$10,000
Less implicit costs:		
Foregone salary	0	50,000
Foregone rent	0	10,000
Foregone interest	0	5,000
Equals profit	\$65,000	\$0

Normal Profit vs Abnormal Profit

- **Normal Profit** means the economic profit is zero.
 - The firm owner is compensated exactly equals to his best alternatives.
 - Firms that fail to make normal profit need to shut down.
- **Abnormal Profit** means the economic profit is positive.
 - The firm owner is compensated more than his best alternatives.

Measuring Costs

In the short run, some costs vary with output, while some remain the same no matter amount of output.

- **Total Cost (TC)** = Fixed Cost + Variable Cost
- **Fixed Cost (FC)** does not vary with output.
 - Usually the cost of fixed inputs, e.g. rent
- **Variable Cost (VC)** increases as output increases.
 - $VC = 0$ when $q = 0$.
 - Usually the cost of variable inputs, e.g. wage

Measuring Costs

In the short run, total output is a function of variable inputs and fixed inputs. Thus,

$$TC = TFC + TVC$$

$$TC = rK + wL$$

- r = rental rate of capital (fixed input)
- w = wage of labor (variable input)

Example: Short-Run Total Cost Function

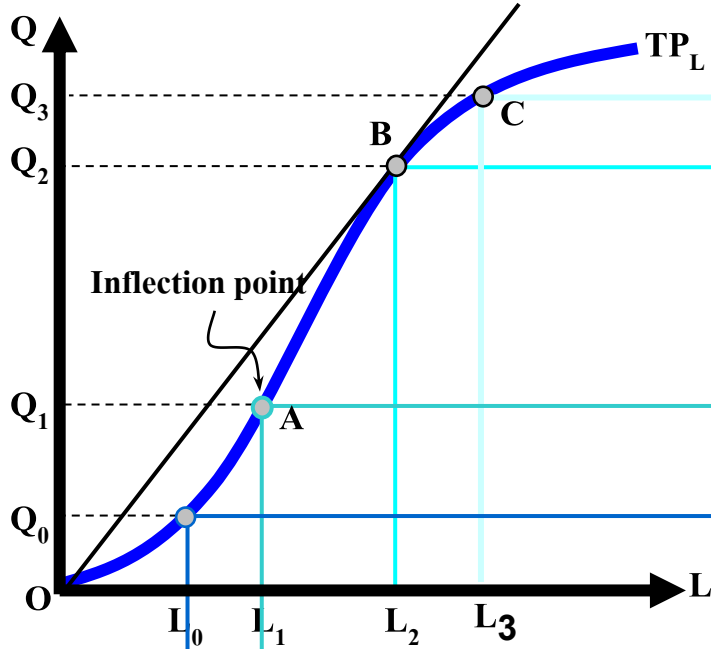
Suppose $Q = K^{0.5}L^{0.5}$ and capital is fixed: $K = 4$.

$$L = \left(Q / K^{0.5} \right)^2 = \left(Q / 4^{0.5} \right)^2 = Q^2 / 4$$

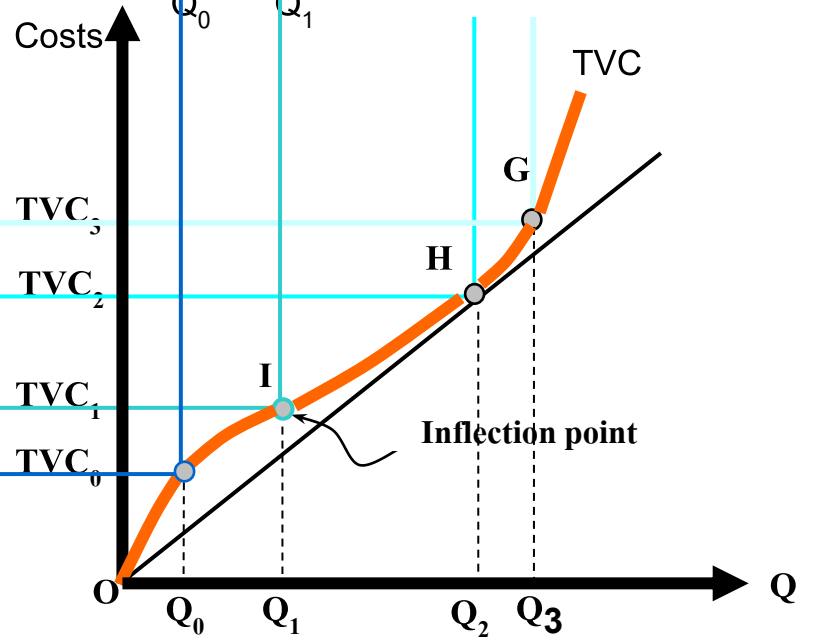
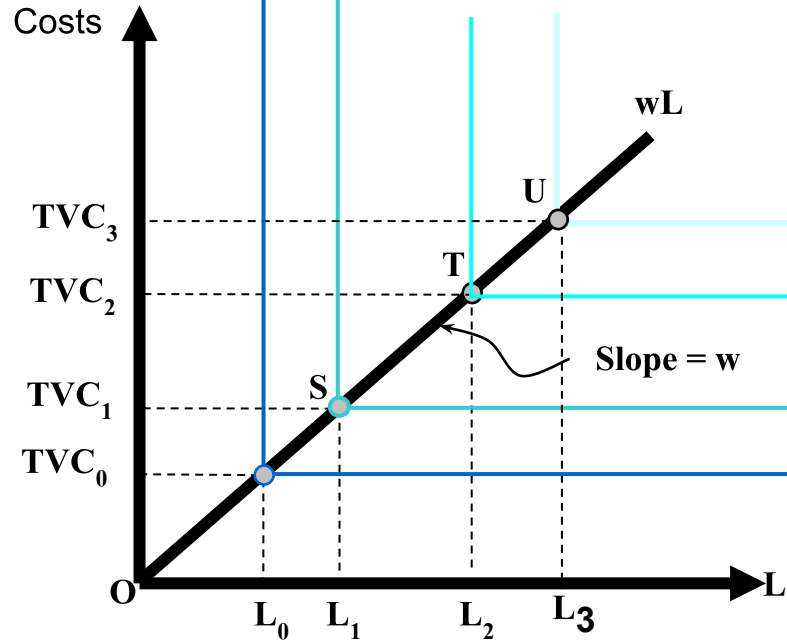
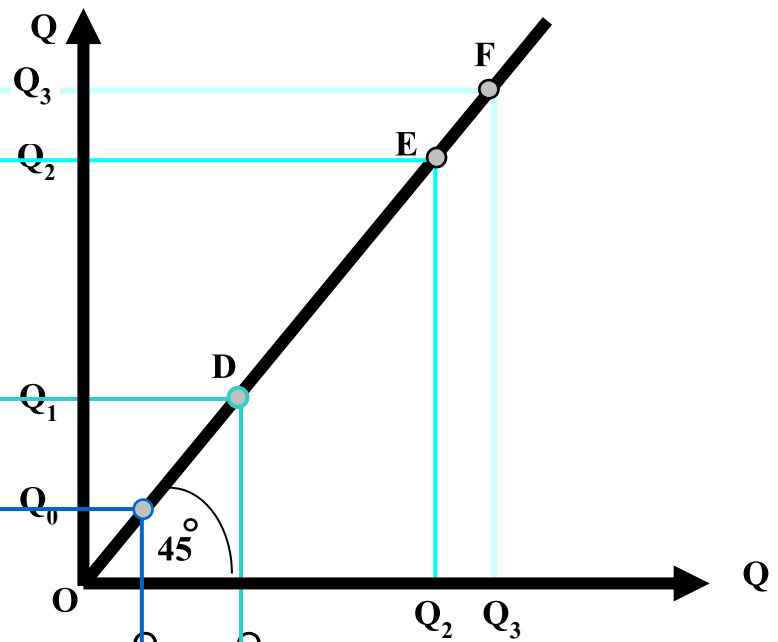
If $r = 10$ and $w = 4$, then

$$\begin{aligned} TC &= rK + wL \\ &= (10)(4) + 4Q^2 / 4 = 40 + Q^2 \end{aligned}$$

(A) TP_L curve that varies with L



(C) 45° Line for switching the axis



(B) TVC that varies with w and L

(D) TVC curve that varies with Q



Measuring Costs

- **Average Total Cost (ATC)**
 - Cost per unit of output
 - ATC also equals average fixed cost (AFC) plus average variable cost (AVC).

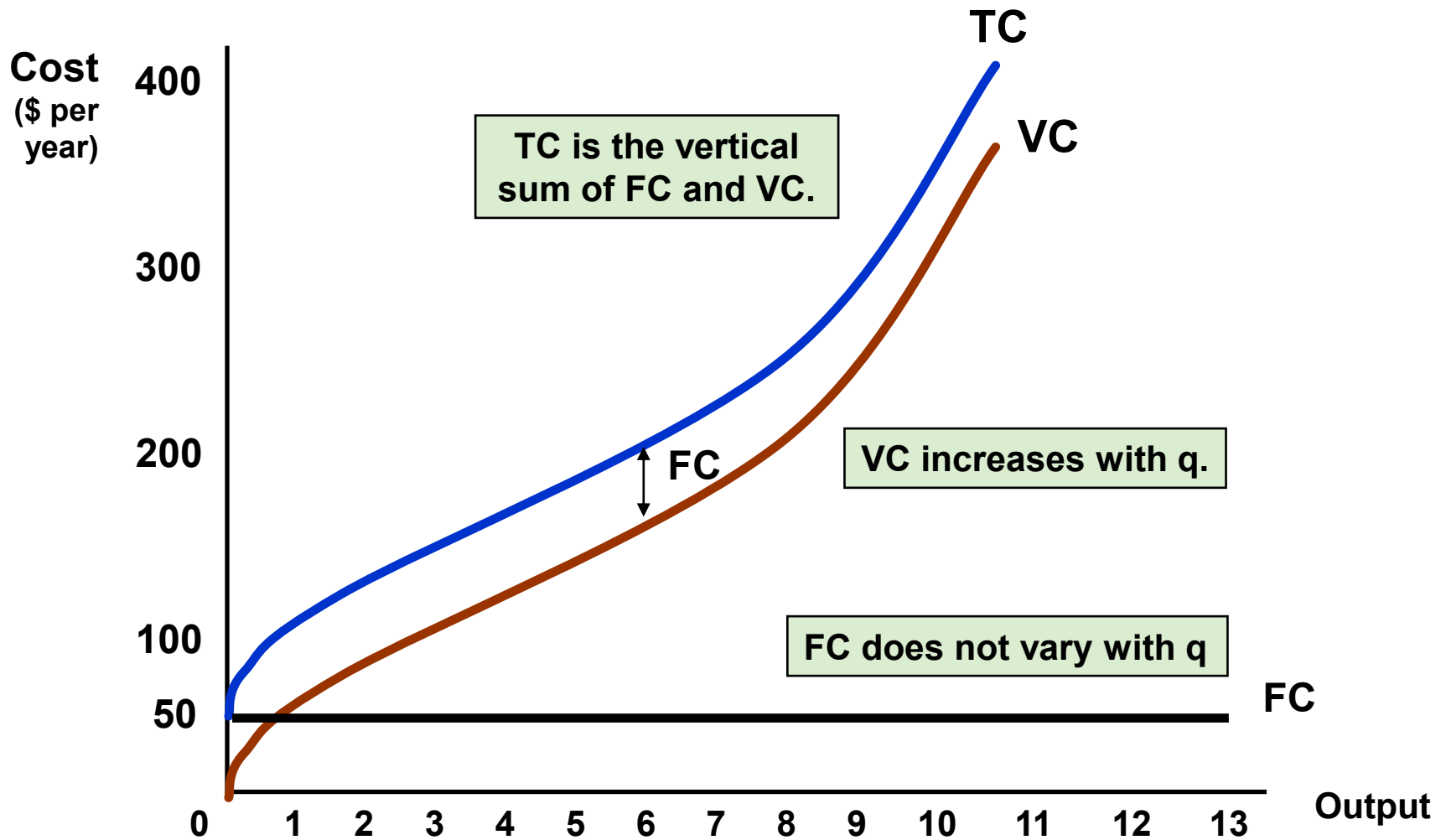
$$\begin{aligned} \text{ATC} &= \frac{\text{TC}}{q} = \text{AFC} + \text{AVC} \\ \text{ATC} &= \frac{\text{TFC}}{q} + \frac{\text{TVC}}{q} \end{aligned}$$

Measuring Costs

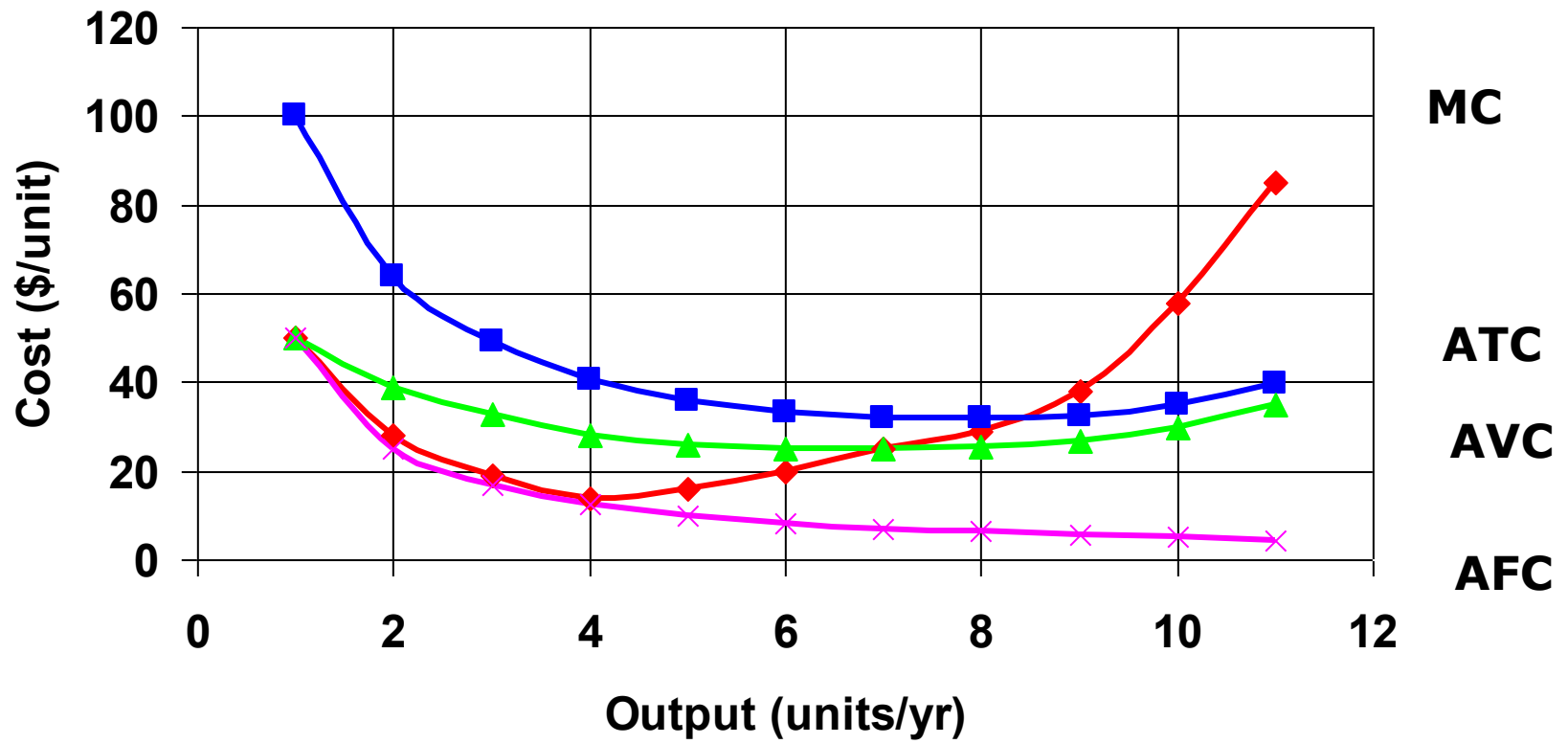
- **Marginal Cost (MC)**
 - Extra cost from producing extra unit of output
 - MC is the slope of TC.
 - TFC does not change with q , so it has no impact on MC.

$$MC = \frac{\Delta TVC}{\Delta q} = \frac{\Delta TC}{\Delta q}$$

Cost Curves



Cost Curves



The Average – Marginal Relationship

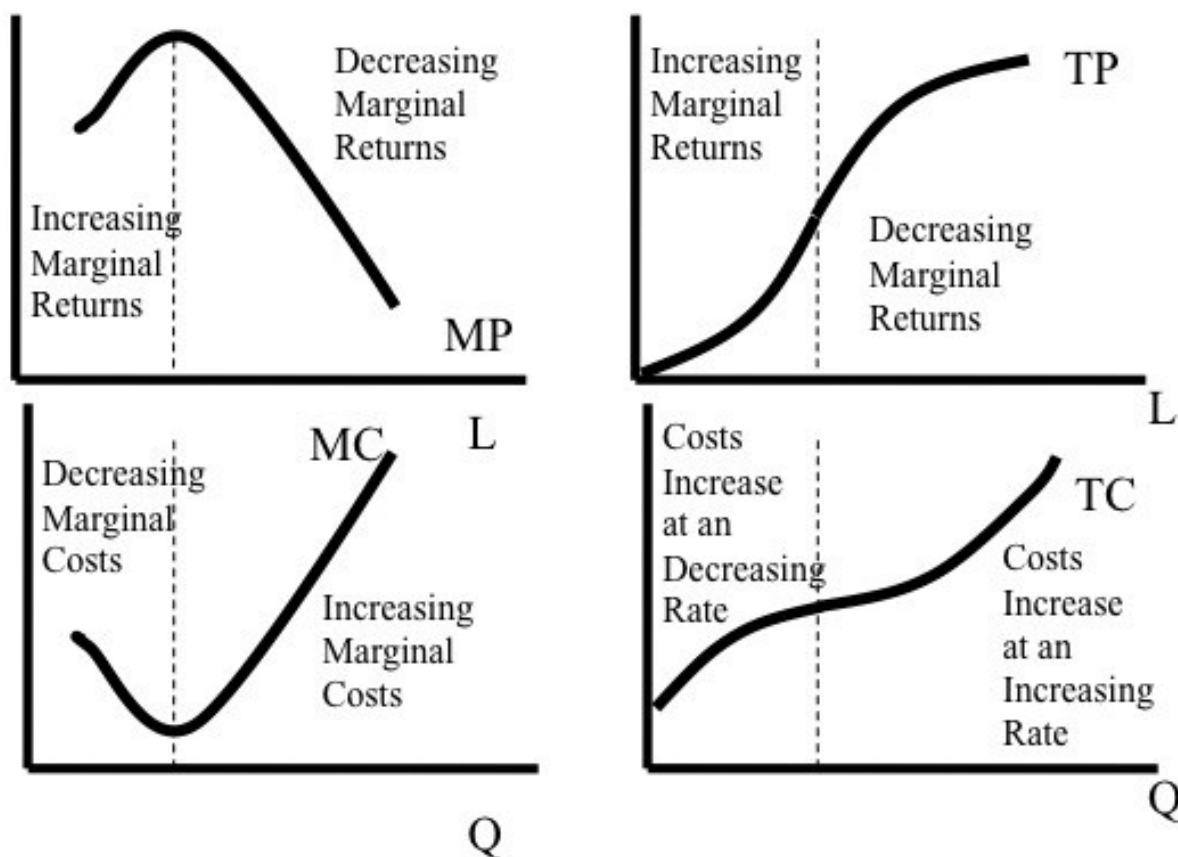
Observations (about MC, AVC, ATC)

- When $MC < AVC$, AVC is falling
- When $MC > AVC$, AVC is rising
- When $MC < ATC$, ATC is falling
- When $MC > ATC$, ATC is rising
- Therefore, MC crosses AVC and ATC at their minimums

Short-Run Production and Costs



Relationships



Short-Run Production and Costs

- Due to Specialization and Division of Labor, first few workers are very productive (**MP increasing**).
 - To produce extra output, fewer extra resources are needed, reducing extra cost (**MC decreasing**).
- Due to the Law of Diminishing Marginal Returns, subsequent workers are less productive (**MP decreasing**).
 - To produce extra output, greater extra resources are needed, raising extra cost (**MC increasing**).

Short-Run Production and Costs

- Assume the wage rate (w) is fixed, so $TVC = wL$.

$$\begin{aligned} MC &= \frac{\Delta TVC}{\Delta q} = \frac{\Delta[wL]}{\Delta q} \\ &= \frac{w\Delta L}{\Delta q} = \frac{w}{MP_L} \end{aligned}$$

- A low marginal product (MP) leads to a high marginal cost (MC), and vice versa.