Production

Economics of enterprise/ Managerial Economics

Concept of Production

- *Production is the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user."*
- Production is **a value addition** process. At each stage of processing, there will be value addition.

Production Theory

- Explains the principles in which the business has to take decisions on how much of each commodity it sells and how much it produces and also how much of raw material, i.e., fixed capital and labor it employs and how much it will use.
- It defines the relationships between the prices of the commodities and productive factors on one hand and the quantities of these commodities and productive factors that are produced on the other hand.

Productive resources, or *inputs*, or *factors of production*

- used by firms to produce goods and services.
- Productive resources may conceptually be divided into two broad categories—human and nonhuman resources
  - Nonhuman resources may be further classified as ***land***, ***raw materials***, **and** ***capital*****.**
  - Human resources, on the other hand, might be classified as ***labor*** **and** ***entrepreneurial ability*****.**

Types of production factors

- **Fixed factors:**
  - These are the factors of production that cannot be changed in the short run.
- **Variable factors**
  - inputs that can be varied in both short and long run

Short run / Long Run

Short run

- the period during which at least one factor input is fixed while other inputs are variable.

Long Run

- the period during which all factors are variable.

Scale

- This term refers to scale of production or organization.
- It relates to **the amount of fixed factors that a firm has**.
- It follows therefore that **a firm cannot change its scale in the short run**.
- A firm's scale determines its capacity;
- It refers to the **maximum output that a firm can produce in the short run**.

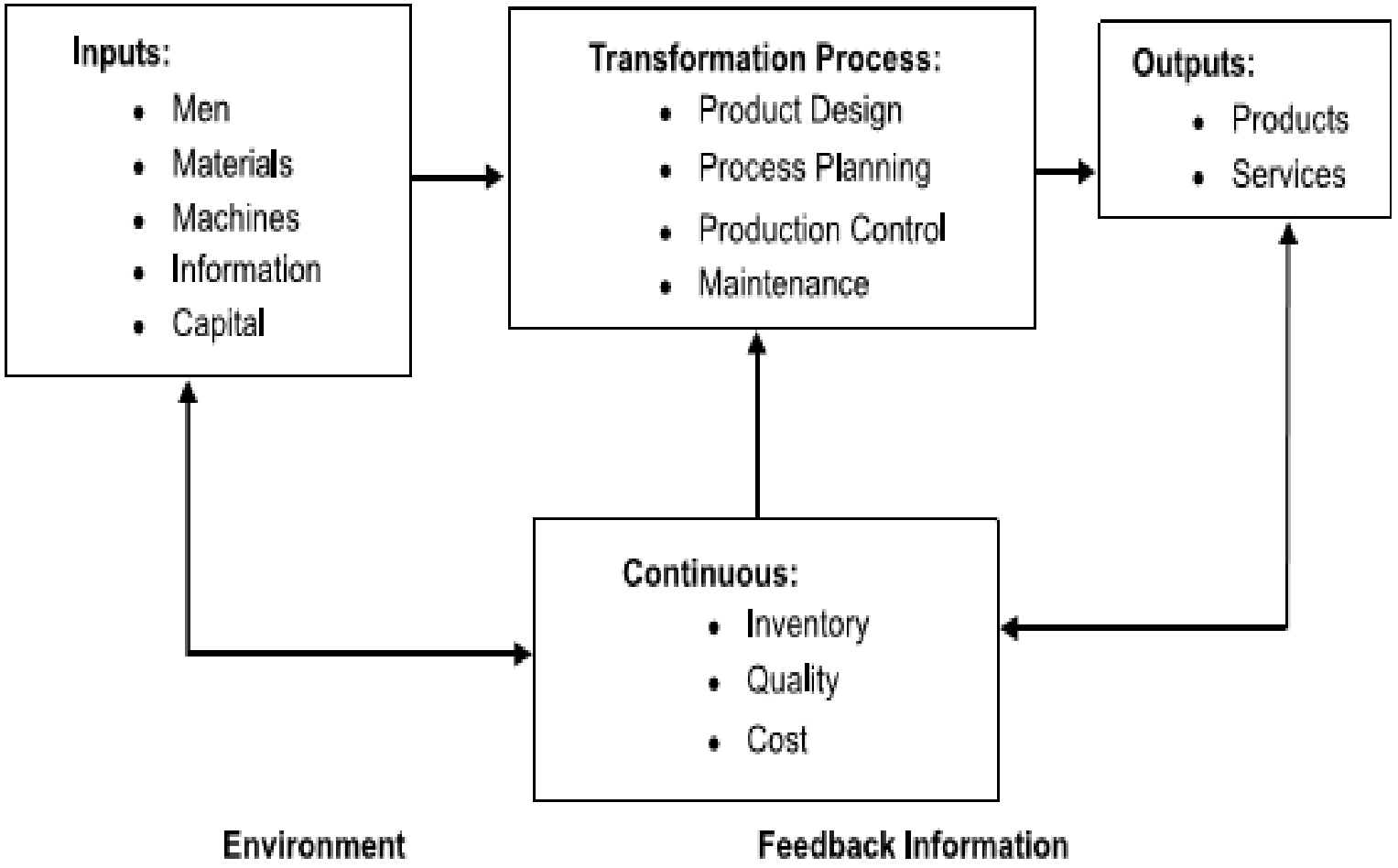
Production system

- The production system of an organization is that part, which produces products of an organization.
- It is that activity whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management

Characteristics of production system

- Production is an organized activity, so every production system has an objective.
- The system transforms the various inputs to useful outputs.
- It does not operate in isolation from the other organization system.
- There exists a feedback about the activities, which is essential to control and improve system performance.

Schematic production system



Porter’s value chain

- The value chain includes a **business' primary activities**. These activities should be run at optimum level if the organization is to gain any real competitive advantage.
- To conduct a value chain analysis, the company begins by identifying each part of its production process and identifying where steps can be eliminated or improvements can be made.
- These improvements can result in **either cost savings** or **improved productive capacity**. The end result is that customers derive the most benefit from the product for the cheapest cost, which improves the company's bottom line in the long run.

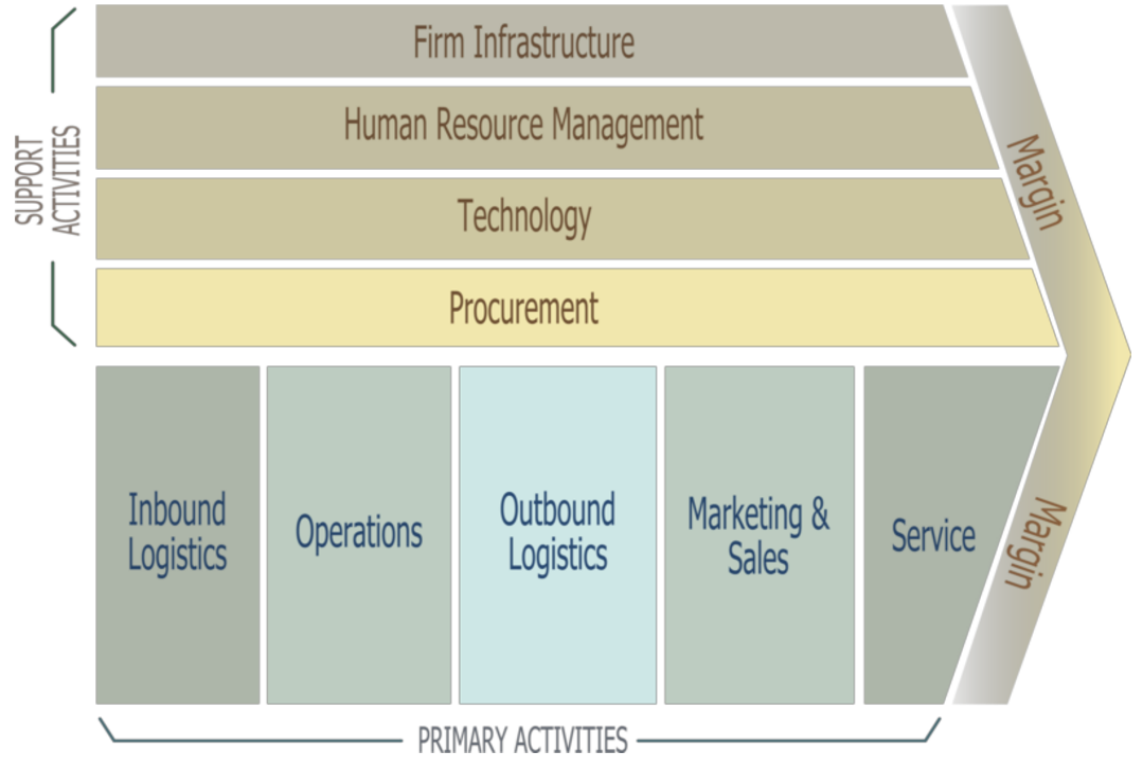
Porter said a business's activities could be split into two categories: **primary activities and support activities**

- **Primary activities**
  - ***Inbound logistics:*** This refers to everything involved in receiving, storing and distributing the raw materials used in the production process.
  - ***Operations:*** This is the stage where raw products are turned into the final product.
  - ***Outbound logistics:*** This is the distribution of the final product to consumers.
  - ***Marketing and sales:*** This stage involves activities like advertising, promotions, sales-force organization, selecting distribution channels, pricing, and managing customer relationships of the final product to ensure it is targeted to the correct consumer groups.
  - ***Service:*** This refers to the activities that are needed to maintain the product's performance after it has been produced. This stage includes things like installation, training, maintenance, repair, warranty and after-sales services

Support activities - help the primary functions

- ***Procurement:*** This is how the raw materials for the product are obtained.
- ***Technology development:*** Technology can be used across the board in the development of a product, including in the research and development stage, in how new products are developed and designed, and process automation.
- ***Human resource management:*** These are the activities involved in hiring and retaining the proper employees to help design, build and market the product.
- ***Firm infrastructure:*** This refers to an organization's structure and its management, planning, accounting, finance and quality-control mechanisms.

Porter's Value Chain



Source: Competitive Advantage. Creating and Sustaining Superior Performance by Michael E. Porter

Production function

- signifies a technical relationship between the physical inputs and physical outputs of the firm, for a given state of the technology
- It is a tool that analysis ***the qualitative input – output relationship*** and also represents the technology of a firm or the economy as a whole.

$$Q = f(a, b, c, \ldots\ldots z)$$

- *where a,b,c ....z are various inputs such as land, labor ,capital etc. Q is the level of the output for a firm.*

- **The production function defines the maximum rate of output per unit of time obtainable from a given set of productive inputs.**

Production Function Analysis

- **A firm that operates efficiently will choose that combination of productive inputs that minimizes the total cost of producing a given level of output**

THE COBB–DOUGLAS PRODUCTION FUNCTION

- The general form of the Cobb–Douglas production function for the two-input case may be written

$$Q = AK^{\alpha}L^{\beta}$$

- where *A*, α and β are known parameters and *K* and *L* represent the explanatory variables capital and labor, respecitvely.
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THE COBB–DOUGLAS PRODUCTION FUNCTION

- A – technological factor
- α – capital elasticity
- β –labor elasticity
- It is further assumed that $0 < (\alpha, \beta) < 1$.

THE COBB–DOUGLAS PRODUCTION FUNCTION

- **Three** important relationships that highlight the desirable mathematical properties of the Cobb–Douglas production function:
  - *substitutability of inputs*
  - *returns to scale,*
  - *the law of diminishing marginal product*

Substitutability

- When a given level of output is generated, factors of production may or may not be substitutable for each other.

- The degree of substitutability of inputs is important because it suggests that managers are able to alter the input mix
required to produce a given level of output in response to changes in input
prices.

Example Substitutability

$$Q = 25K^{0.5}L^{0.5}$$

	Labor							
Capital	1	2	3	4	5	6	7	8
1	25	35	43	50	56	61	66	71
2	35	50	61	71	79	87	94	100
3	43	61	75	87	97	106	115	**122**
4	50	71	87	100	112	**122**	132	141
5	56	79	97	112	125	137	148	158
6	61	87	106	**122**	137	150	162	173
7	66	94	115	132	148	162	175	187
8	71	100	**122**	141	158	173	187	200

Returns to Scale

- Suppose that output is described as a function of capital and labor.
- Suppose that capital and labor are multiplied by some scalar.
- **3 types of returns to scale**
  - *constant returns to scale (CRTS)*
  - *increasing returns to scale (IRTS)*
  - *decreasing returns to scale (DRTS)*

Returns to Scale

- ***constant returns to scale*** *(CRTS)* - output increases by that same scalar

– If capital and labor are multiplied by a scalar and output increases by a multiple greater than the scalar, the condition is referred to **as *increasing returns to scale (IRTS)***

– if capital and labor are multiplied by a scalar and output increases by a multiple less than the scalar, the condition is referred to as ***decreasing returns to scale (DRTS)***

Law of Diminishing Marginal Product

- ***when at least one productive input is held fixed while at least one other productive resource is increased, output will also increase but by successively smaller increments.***
- **The law of diminishing marginal product is a short-run production concept**

Short Run Production Function:

- In the short run, some inputs (land, capital) are fixed in quantity.
  The output depends on how much of other variable inputs are used.
- $$Q_L = f(K_0, L) = TP_L$$

$$Q_K = f(K, L_0) = TP_K$$

Total, marginal and average product

- **Total production (TP):** the maximum level of output that can be produced with a given amount of input.
- **Average Production (AP):** output produced per unit of input AP = Q/L AP = Q/K
- **Marginal Production (MP):** the change in total output produced by the last unit of an input
- **Marginal production of labour** = Δ Q / Δ L (i.e. change in the quantity produced to a given change in the labour)
- **Marginal production of capital** = Δ Q / Δ K (i.e. change in the quantity produced to a given change in the capital)

Cobb–Douglas production function and marginal product

$$MP_L = \frac{\partial Q_L}{\partial L} = \beta A K^{\alpha} L^{\beta-1}$$

$$MP_K = \frac{\partial Q_K}{\partial K} = \alpha A K^{\alpha-1} L^{\beta}$$

Example of production function

$$Q = 4LK + 0.1L^2K + 0.2LK^2 - 0.04L^3K - 0.02LK^3$$

- Calculate Production function if K=3 is constant

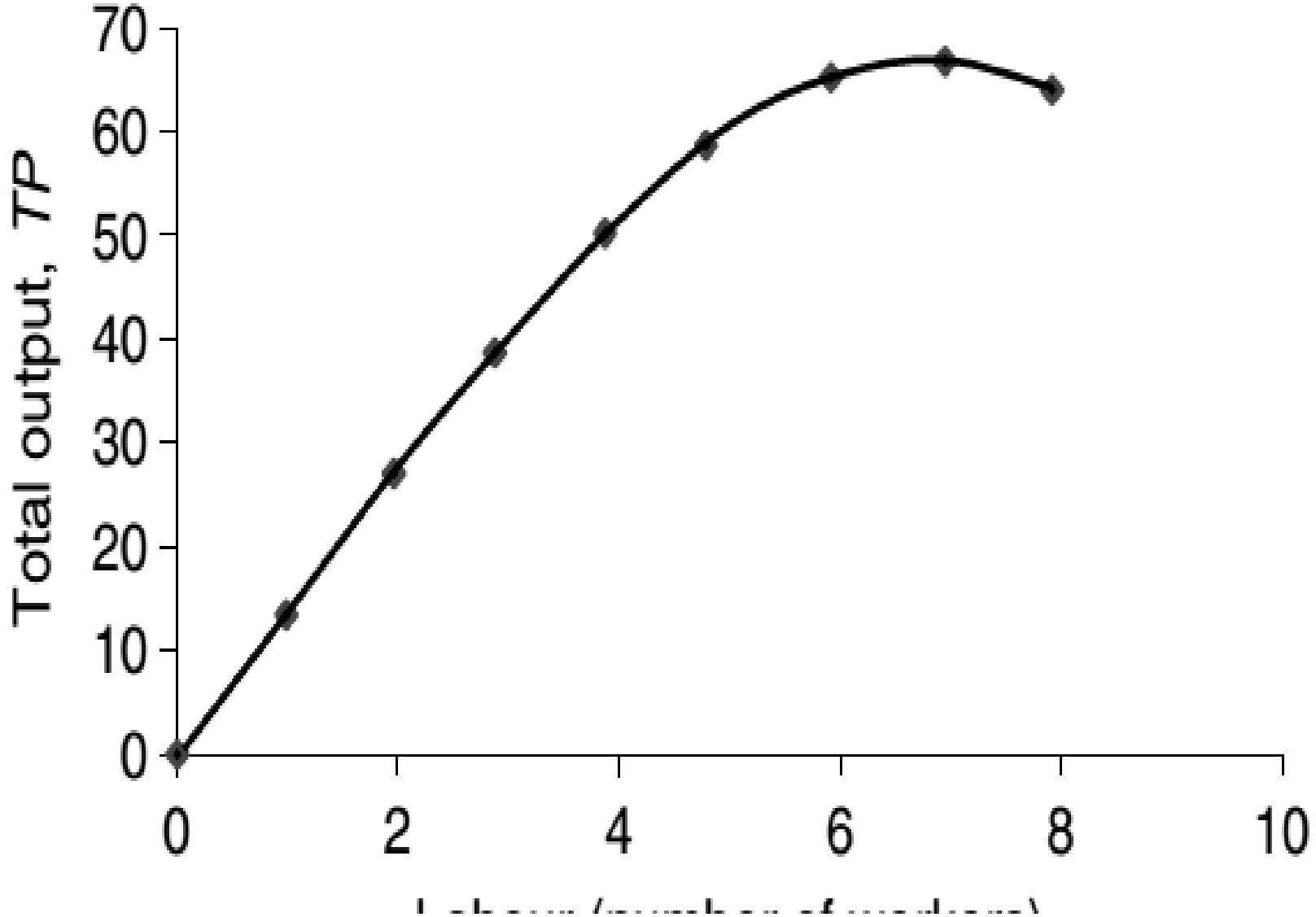
$$Q = 13.26L + 0.3L^2 - 0.12L^3$$

- Calculate TP, AP, MP if L ={0;7}

$$MP = \partial Q/L = 13.26 + 0.6L - 0.36L^2$$

$$AP = Q/L = 13.26 + 0.3L - 0.12L^2$$

Labour input, *L*	Total output, *Q*	Marginal product, *MP*	Average product, *AP*
0	0		–
		13	
1	13		13
		14	
2	27		13.5
		12	
3	39		13
		11	
4	50		12.5
		9	
5	59		11.8
		5	
6	64		10.7
		2	
7	66		9.4
		–2	
8	64		8


Total output, TP
70
60
50
40
30
20
10
0
0
2
4
6
8
10


15
10
5
0
–5
MP, AP
AP
MP
0
2
4
6
8
10
Labour (number of workers)

Increasing and diminishing returns

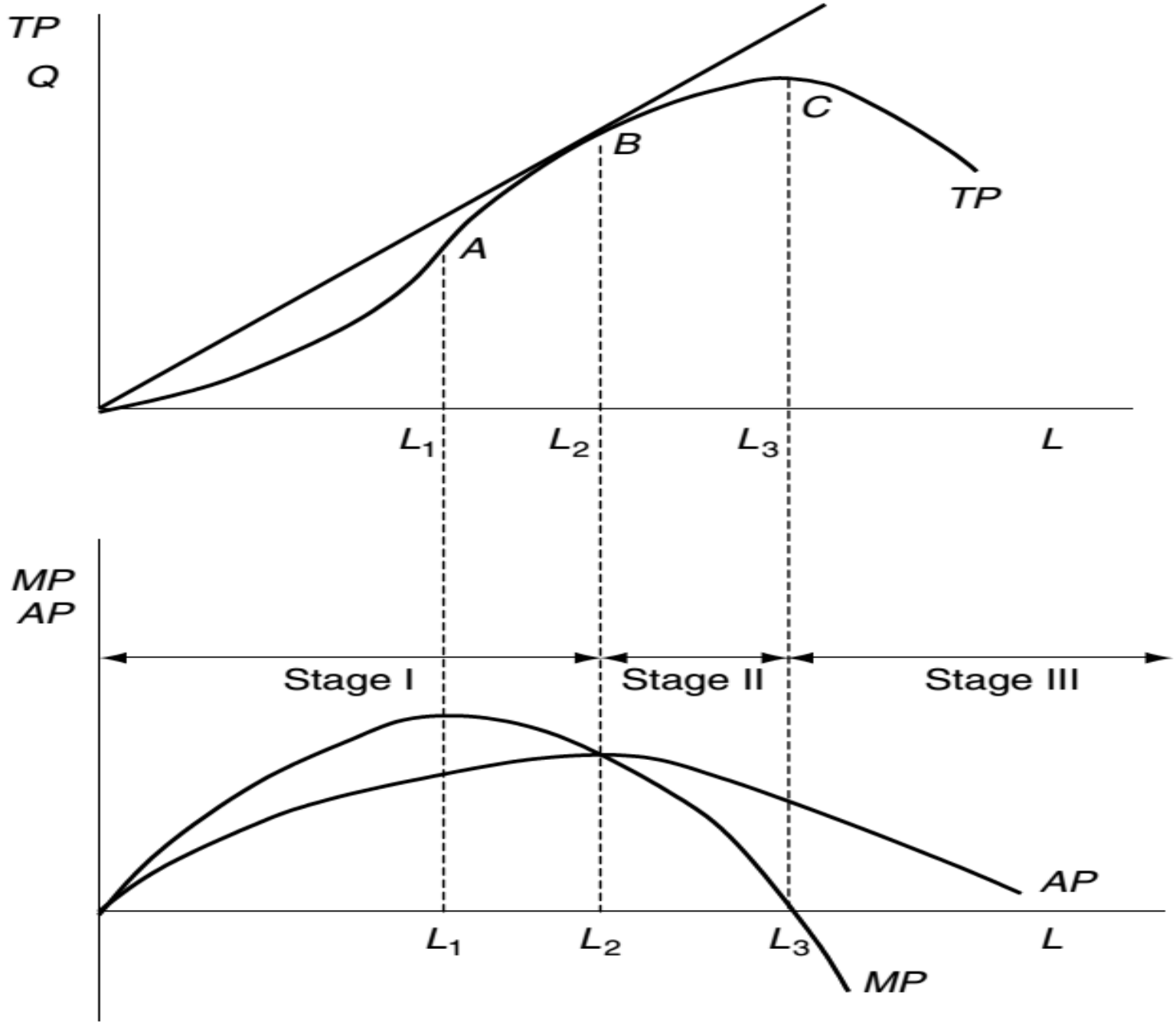
- Increasing returns - Increase in output that is proportionally greater than a simultaneous and equal percentage change in the use of all inputs.
  - **When – fixed factor is underutilized**;
    - specialization

Diminishing returns

- when additional units of a variable factor are combined with a fixed amount of another factor(s) the additions to total output, in other words the marginal product, will eventually decline.
  - **fixed factor is becoming overutilized**

Relationships between total, marginal and average product

- **Point A** – TP curve is convex (to the horizontal axis) from the origin to point A.
  - As more of the variable input is used the curve now becomes concave, meaning that the slope is decreasing.
  - The slope of the TP curve is given by $\delta Q/\delta L$, and this represents the marginal product (MP).
- **Thus the MP is at a maximum at point A, corresponding to the level of input L1**


TP
Q
A
B
C
TP
L1
L2
L3
L
MP
AP
Stage I
Stage II
Stage III
AP
L1
L2
L3
L
MP

Relationships between total, marginal and average product

- **Point B.**
  The slope of the line, or ray, from the origin to the TP curve is given by Q/L and this represents the average product (AP).
- This slope is at a maximum when the line from the origin is tangential to the TP curve, at point B.
- This corresponds to the level of input L_2. It can also be seen that this occurs when **AP and MP are equal**

Relationships between total, marginal and average product

- when MP is above AP, AP must be rising (up to input level L2)
- when MP is below AP, AP must be falling
- when AP and MP are equal, AP remains unchanged and must therefore be a maximum (it is no longer rising and is about to fall)

Relationships between total, marginal and average product

- **Point C.** The TP curve reaches a peak or maximum at point C;
- this means that the slope is 0 and therefore MP is 0. This corresponds to the level of input L_3.
  Above this level of input TP declines and MP becomes negative

Stages of production process

- **Stage I.** This corresponds to the input range between zero and L_2, where **AP reaches a maximum.**
- **Stage II.** This corresponds to the input range between L_2 and L_3, where **AP is falling but TP is still rising, meaning that MP is still positive.**
- **Stage III**. This corresponds to the input range beyond L_3, **where TP is falling, meaning that MP is negative.**

The use of production function

- a firm that is operating with economic efficiency will **never produce in the stage III region**. This is because it is possible to produce the same total output with less of the variable input and therefore less cost.
- if it is operating in a perfectly competitive environment, **the firm should produce in the stage II region in order to maximize profit**.

ISOQUANTS

- because of the **substitutability of productive inputs**, for many productive processes it may be possible to utilize labor and capital in an infinite number of combinations (assuming that productive resources are infinitely divisible)
- **Definition: An isoquant defines the combinations of capital and labor (or any other input combination in *n*-dimensional space) necessary to produce a given level of output.**
  - *infinite number of such isoquants are possible corresponding to an infinite number of theoretical output levels*

Example Substitutability

$$Q = 25K^{0.5}L^{0.5}$$

	Labor							
Capital	1	2	3	4	5	6	7	8
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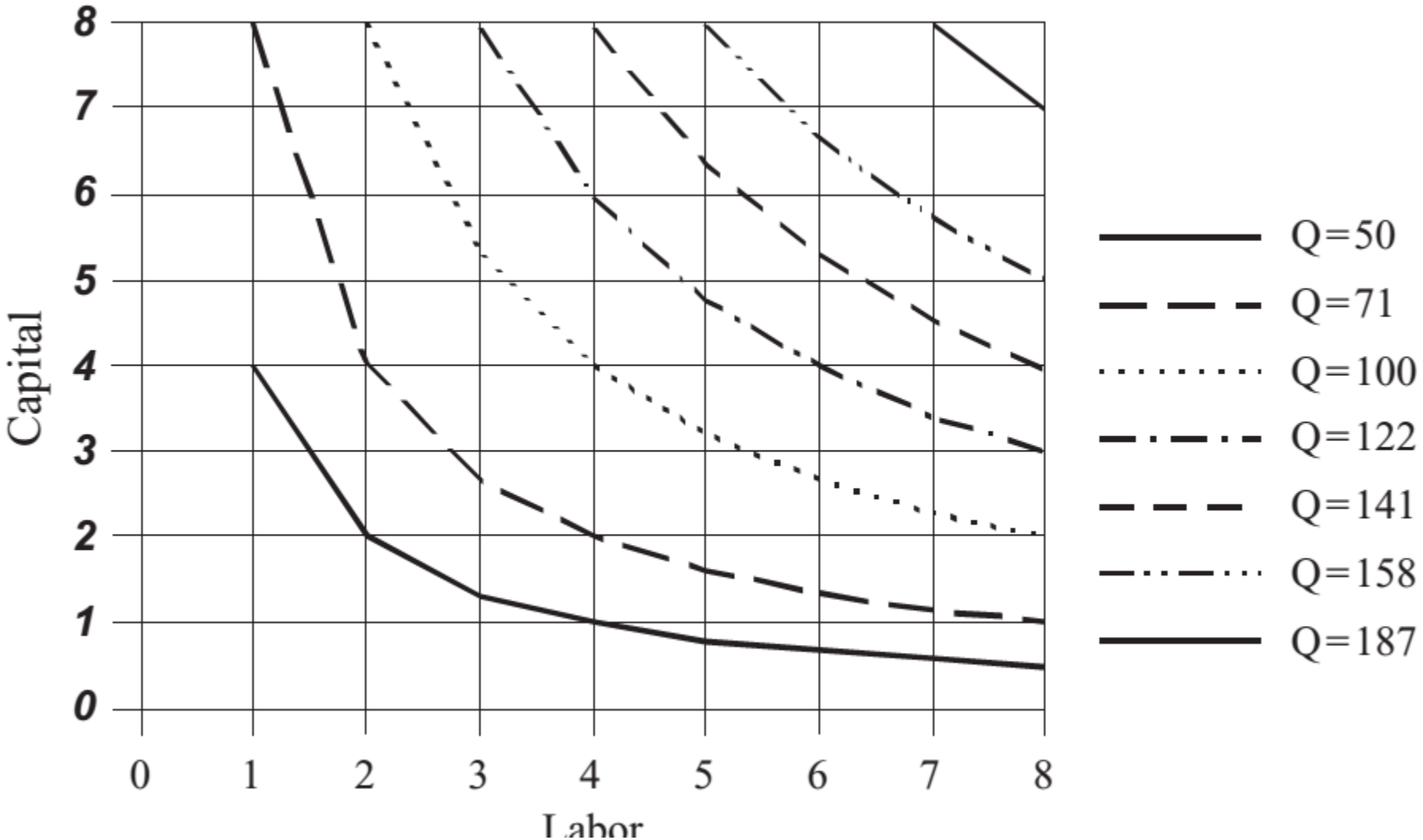
ISOQUANTS MAP

- For any given production function there are an infinite number of isoquants in an **isoquant map**
- Function of isoquants map $Q_0 = f(K, L)$
- **The slope of an isoquant** measures the rate at which **capital and labor can be substituted for each other to yield a constant rate of output**

$$\frac{dK}{dL} = g_K(L, Q_0) = MRTS_{KL} < 0$$

ISOQUANTS MAP



$MRTS_{KL}$

- $MRTS_{KL}$ - *marginal rate of technical substitution* of capital for labor
- $MRTS_{KL}$ says that to maintain a fixed output level, an increase (decrease) in the use of capital must be accompanied by a decrease (increase) in the use of labor.

$$MRTS_{KL} = -\frac{MP_L}{MP_K}$$

Characteristic of isoquants

- inputs are not perfectly substitutable and that the rate of substitution declines as one input is substituted for another.
- ***MP_L declines as more labor is added by the law of diminishing marginal product, MP_K increases as less capital is used***

Production in long-term period

- Long run in production describes the situation in which all factors of production are variable.
- ***A firm that increases its employment of all factors of production may be said to have increased its scale of operations.***

RETURNS TO SCALE

- Returns to scale refer to the proportional increase in output given some equal proportional increase in all productive inputs.

Types of return to scale

- **Constant returns to scale (CRTS)** refers to the condition where **output increases in the same proportion as the equal proportional increase in all inputs.**
- **Increasing returns to scale (IRTS)** occur when **the increase in output is more than proportional to the equal proportional increase in all inputs**.
- **Decreasing returns to scale (DRTS**) occur when **the proportional increase in output is less than proportional increase in all inputs**.

The Cobb–Douglas production function and return to scale

$\alpha + \beta$	Returns to scale
<1	Decreasing
$=1$	Constant
>1	Increasing