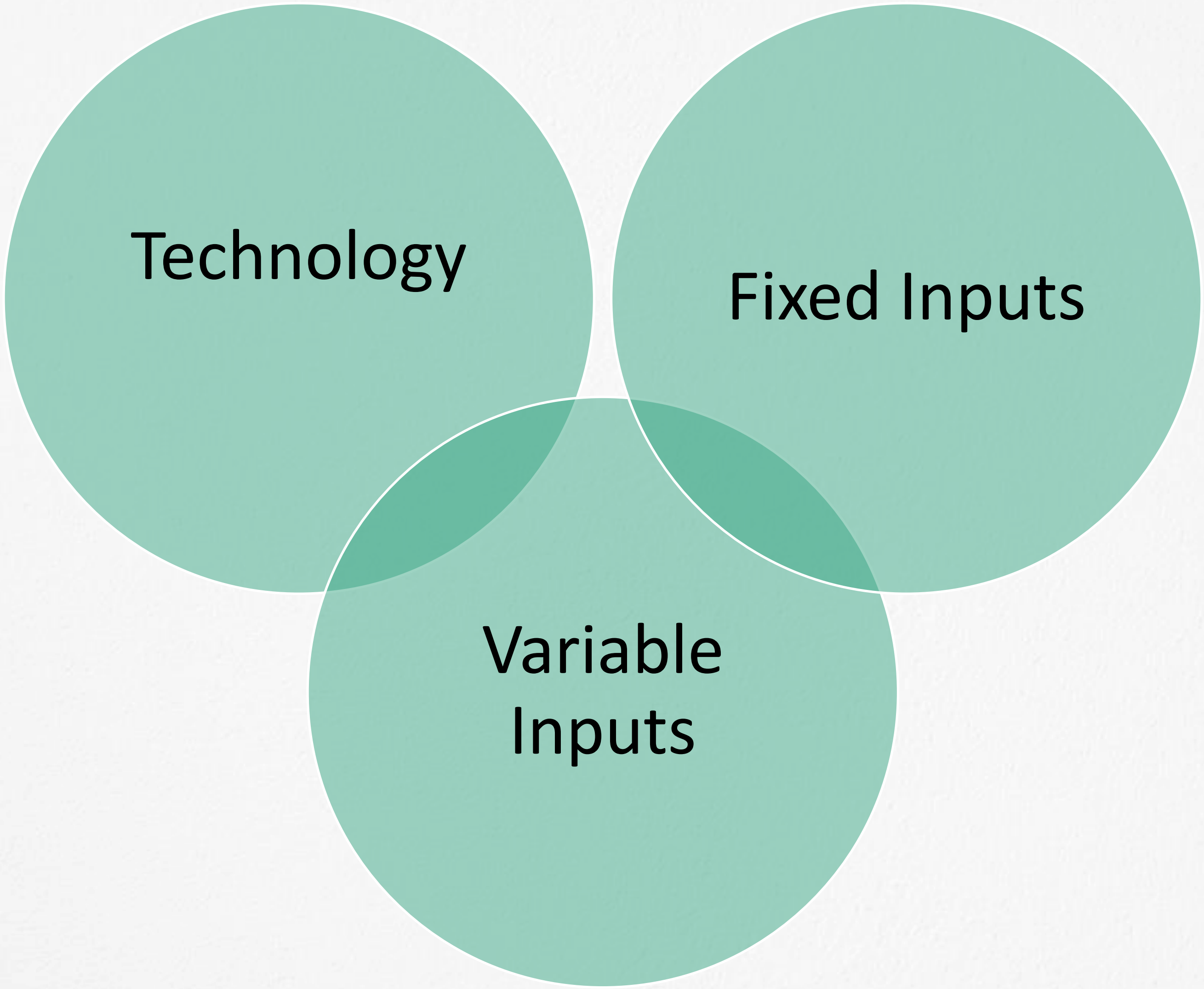
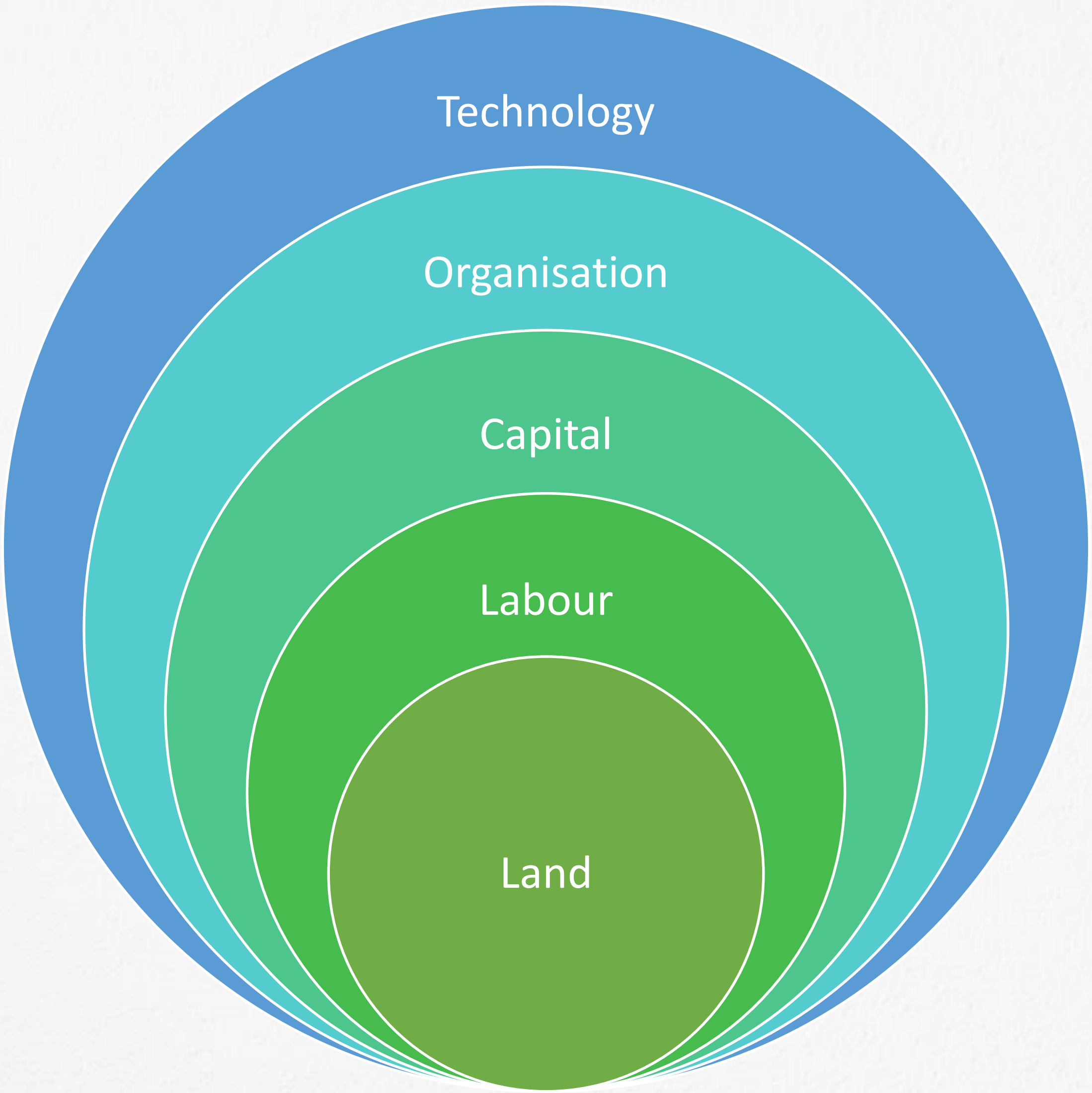
Production

- The conversion of inputs into outputs by applying the factors of production.
- The products manufactured are of use for the consumers.

Types of Inputs



Factors of Production



Production Function

- **Production function:** defines the relationship between inputs and the maximum amount that can be produced within a given period of time with a given level of technology

$$Q = f(X_1, X_2, \ldots, X_k)$$

Q = level of output

$X_1, X_2, \ldots, X_k$ = inputs used in production

Production Function

- The production function can be rewritten so as to include the various factors of production.

$$\mathbf{Q = f(L, K, l, E, T)}$$

Where L: Labour

K: Capital

l: Land

E: Enterprise

T: Technology

Production Function

- Additional key assumptions
  - A given ‘state of the art’ production technology
  - Whatever input or input combinations are included in a particular function, the output resulting from their utilization is at the maximum level.
  - The measure of *quantity* is not a measure of accumulated output, but the inputs and output for a specific period of time.

Production Function with One Variable

- This is a short run production function.
- For simplicity we will often consider a production function of two inputs:

$$Q = f(L, \overline{K})$$

Q = output

L = labor

$\overline{K}$ = fixed capital

Production Function

- **Short-run production function:** the maximum quantity of output that can be produced by a set of inputs
  - Assumption: the amount of at least one of the inputs used remains unchanged

- **Long-run production function:** the maximum quantity of output that can be produced by a set of inputs
  - Assumption: the firm is free to vary the amount of all the inputs being used

Production Function

- **Short-run production function:** the maximum quantity of output that can be produced by a set of inputs
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- **Long-run production function:** the maximum quantity of output that can be produced by a set of inputs
  - Assumption: the firm is free to vary the amount of all the inputs being used

Short-run Analysis of Total, Average, and Marginal Product

- Alternative terms in reference to inputs
  - ‘inputs’
  - ‘factors’
  - ‘factors of production’
  - ‘resources’
- Alternative terms in reference to outputs
  - ‘output’
  - ‘quantity’ (Q)
  - ‘total product’ (TP)
  - ‘product’

Short-run Analysis of Total, Average, and Marginal Product

- **Marginal product** (MP) = change in output (Total Product) resulting from a unit change in a variable input

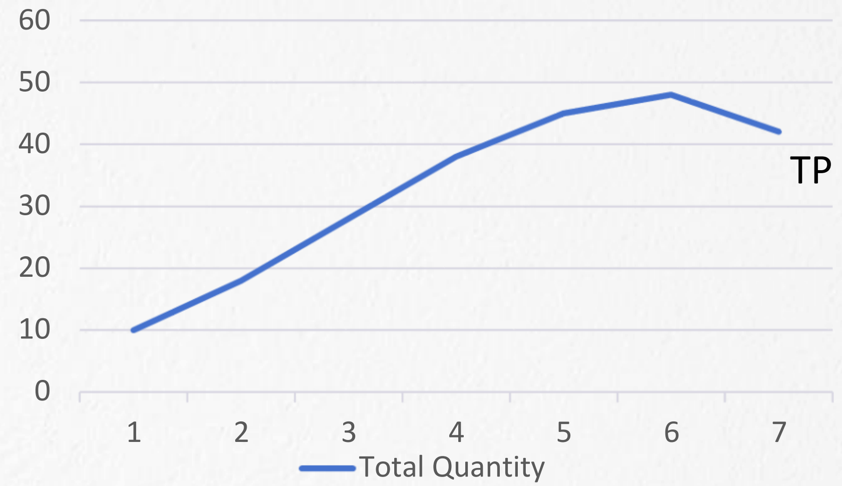
$$MP_L = \frac{\Delta TP}{\Delta L}$$

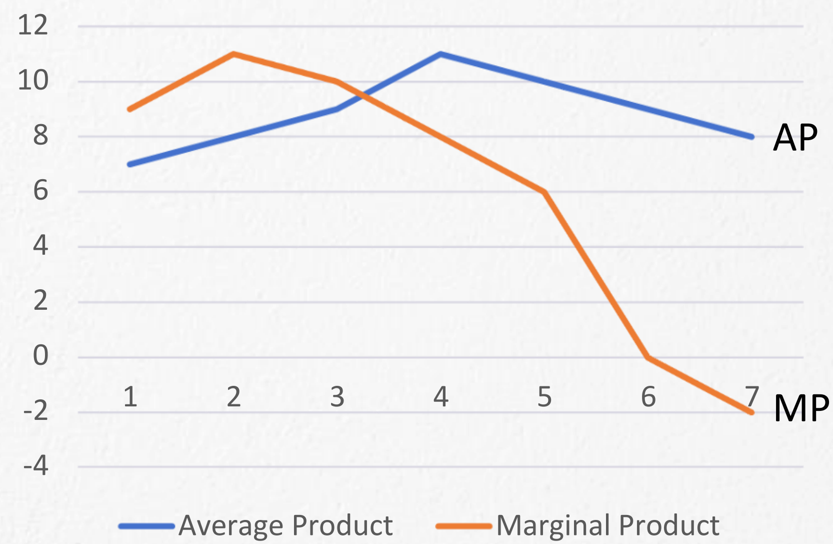
- **Average product** (AP) = Total Product per unit of input used

$$AP_K = \frac{TP}{K} \qquad AP_L = \frac{TP}{L}$$

Short-run Analysis of Total, Average, and Marginal Product

- if MP > AP then AP is rising
- if MP < AP then AP is falling
- MP=AP when AP is maximized





Short-run Analysis of Total, Average, and Marginal Product

Law of variable proportions: as additional units of a variable input are combined with a fixed input, after some point the additional output (i.e., marginal product) starts to diminish

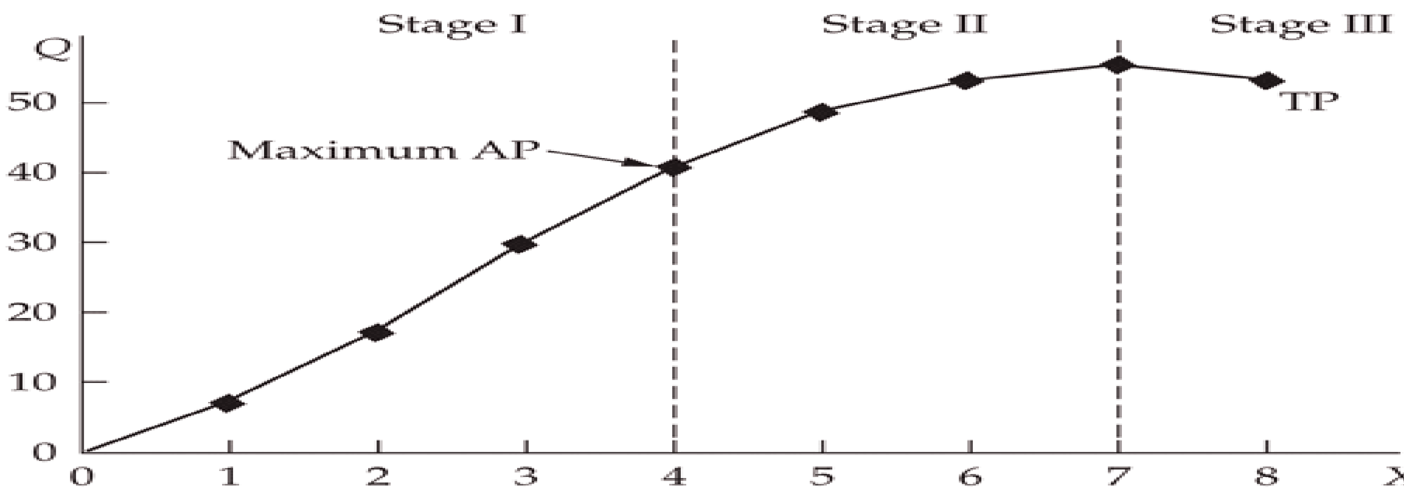
- nothing says *when* diminishing returns will start to take effect
- all inputs added to the production process have the same productivity

Short-run Analysis of Total, Average, and Marginal Product

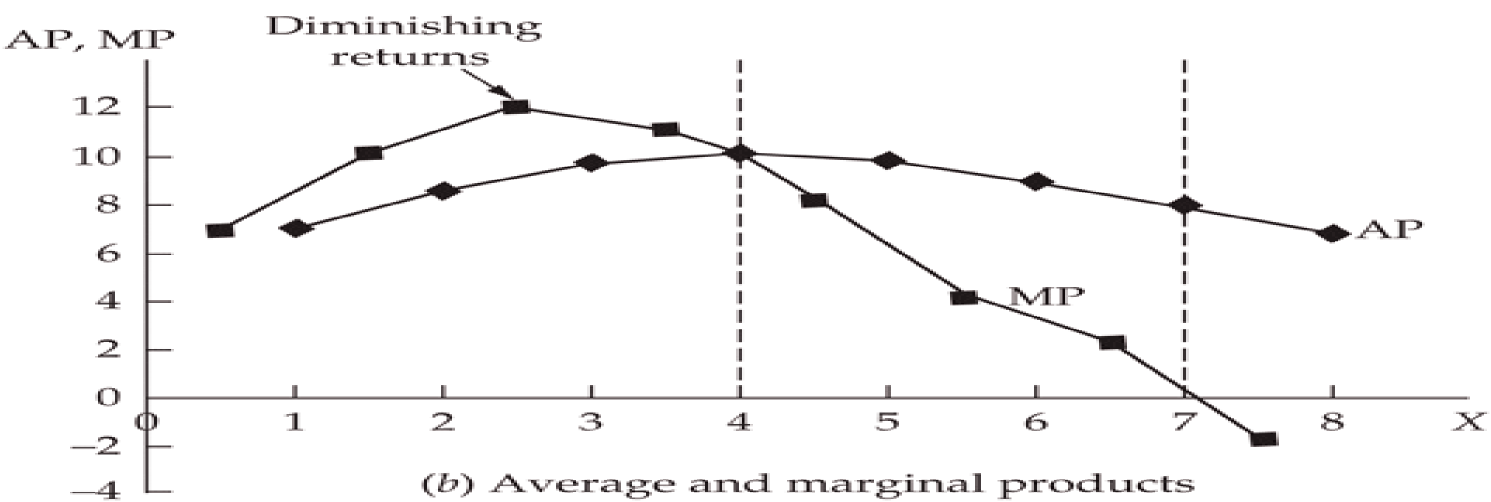
The **Three Stages of Production** in the short run:

- Stage I: from zero units of the variable input to where AP is maximized (where MP=AP)
- Stage II: from the maximum AP to where MP=0
- Stage III: from where MP=0

Short-run Analysis of Total, Average, and Marginal Product



(a) Total product



(b) Average and marginal products

Short-run Analysis of Total, Average, and Marginal Product

In the short run, rational firms should be operating only in Stage II

Q: Why not Stage III? → firm uses more variable inputs to produce less output

Q: Why not Stage I? → underutilizing fixed capacity, so can increase output per unit by increasing the amount of the variable input

Short-run Analysis of Total, Average, and Marginal Product

What level of input usage within Stage II is best for the firm?

The answer depends upon:

- how many units of output the firm can sell
- the price of the product
- the monetary costs of employing
- the variable input

Short-run Analysis of Total, Average, and Marginal Product

Total revenue product (TRP) = market value of the firm's output, computed by multiplying the total product by the market price.

$$TRP = Q \cdot P$$

Short-run Analysis of Total, Average, and Marginal Product

Marginal revenue product (MRP) = change in the firm's TRP resulting from a unit change in the number of inputs used

$$\frac{\Delta TRP}{\Delta X}$$

$$MRP = MP \cdot P$$

Short-run Analysis of Total, Average, and Marginal Product

- **Total labor cost** (TLC) = total cost of using the variable input labor, computed by multiplying the wage rate by the number of variable inputs employed

$$TLC = w \cdot X$$

- **Marginal labor cost** (MLC) = change in total labor cost resulting from a unit change in the number of variable inputs used

$$MLC = w$$

Short-run Analysis of Total, Average, and Marginal product

Summary of relationship between demand for output and demand for a single input:

A profit-maximizing firm operating in perfectly competitive output and input markets will be using the optimal amount of an input at the point at which the monetary value of the input's marginal product is equal to the additional cost of using that input

$$MRP = MLC$$

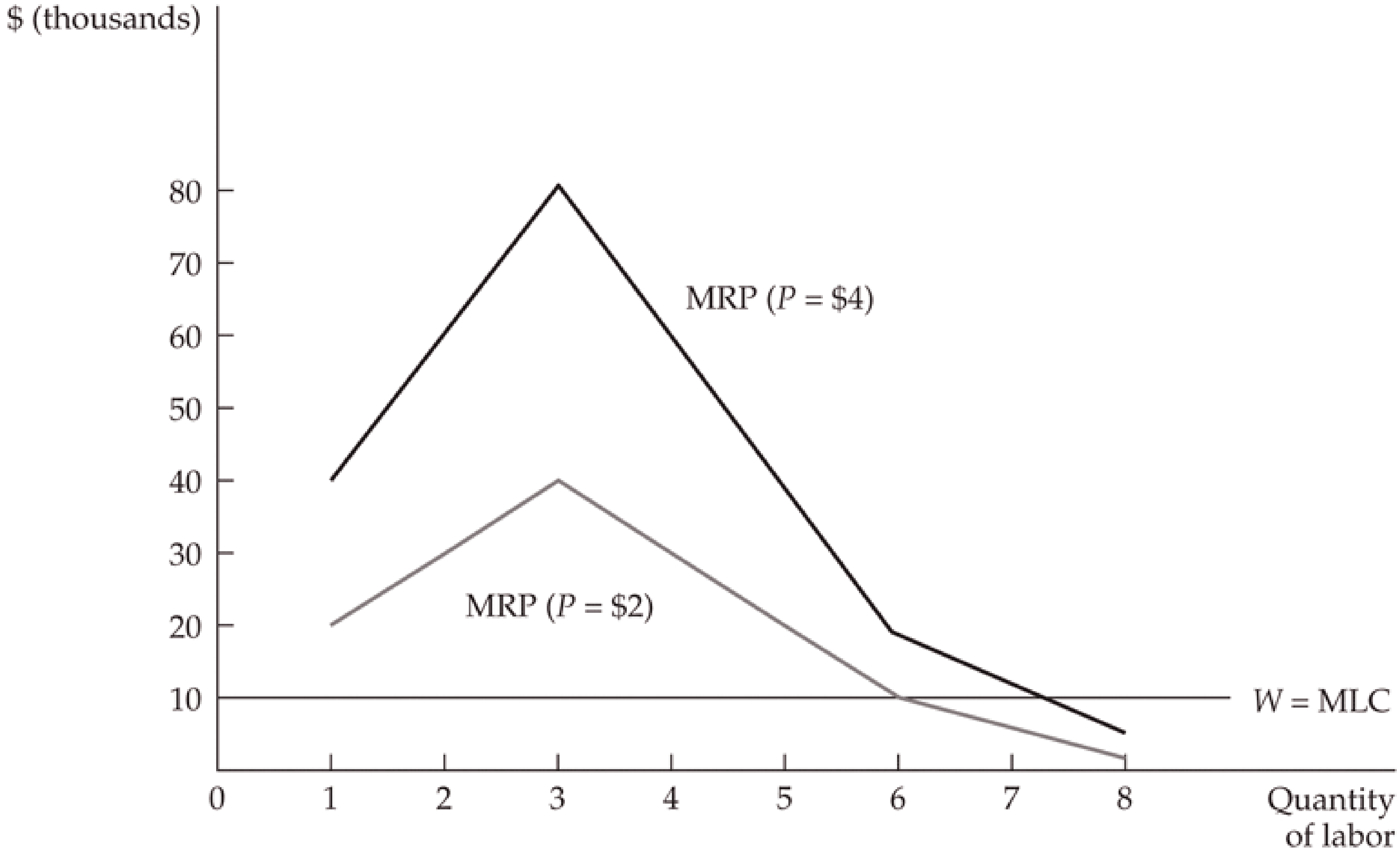
Short-run Analysis of Total, Average, and Marginal Product

Multiple variable inputs

- Consider the relationship between the ratio of the marginal product of one input and its cost to the ratio of the marginal product of the other input(s) and their cost

$$\frac{MP_1}{w_1} = \frac{MP_2}{w_2} = \frac{MP_k}{w_k}$$

Short-run Analysis of Total, Average, and Marginal Product



Production Function With Two Variable Inputs

- This is a long run concept.
- All the inputs are variable in nature.
- The firm selects a combination of inputs which lead to optimum production.
- This is understood with the help of Isoquants.

Production Function With Two Variable Inputs

- An isoquant is the locus of all technically efficient combinations for producing a given level of output.

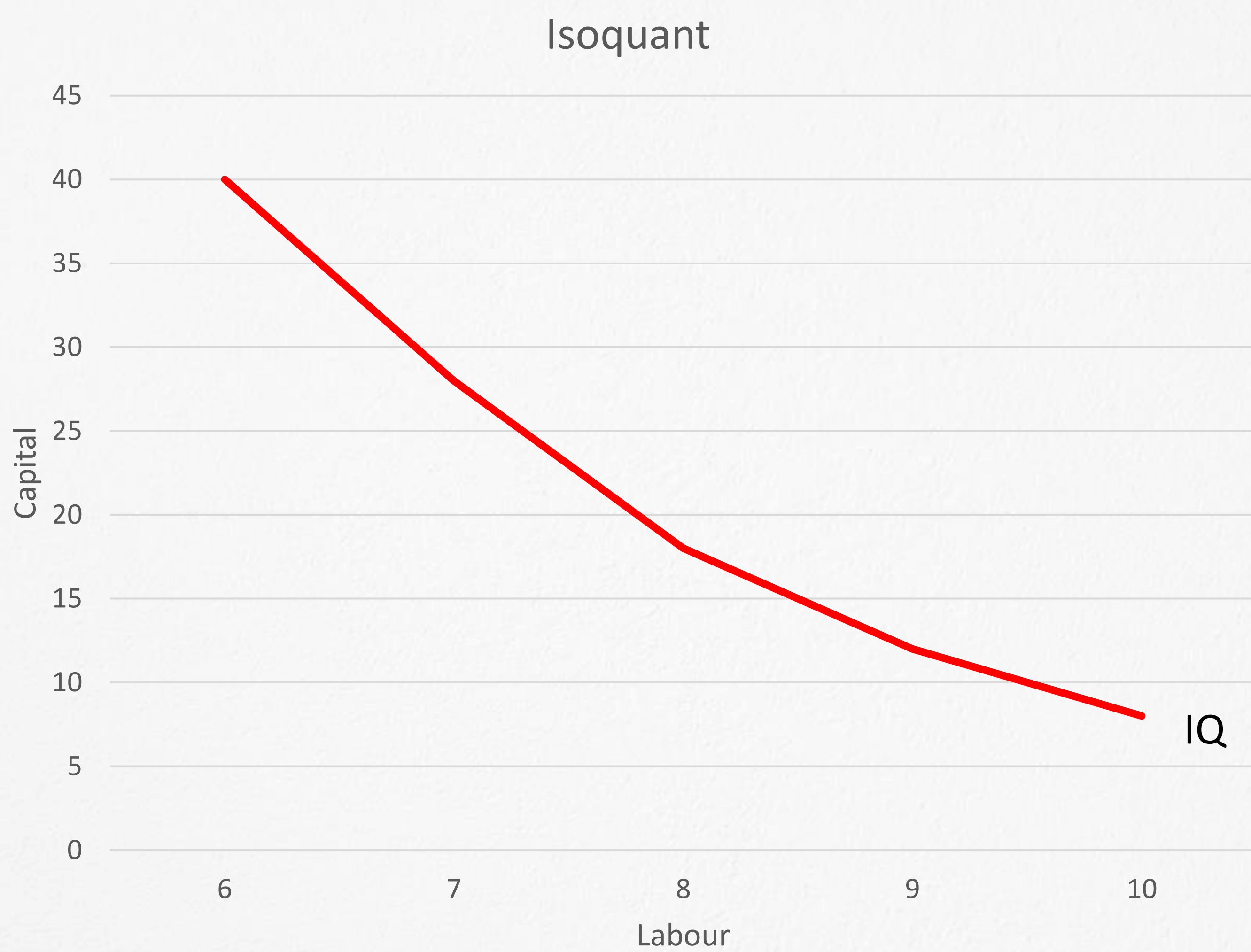
$$\overline{Q} = f(L, K)$$

- where $\overline{Q}$ = constant output

  L = Labour

  K = Capital

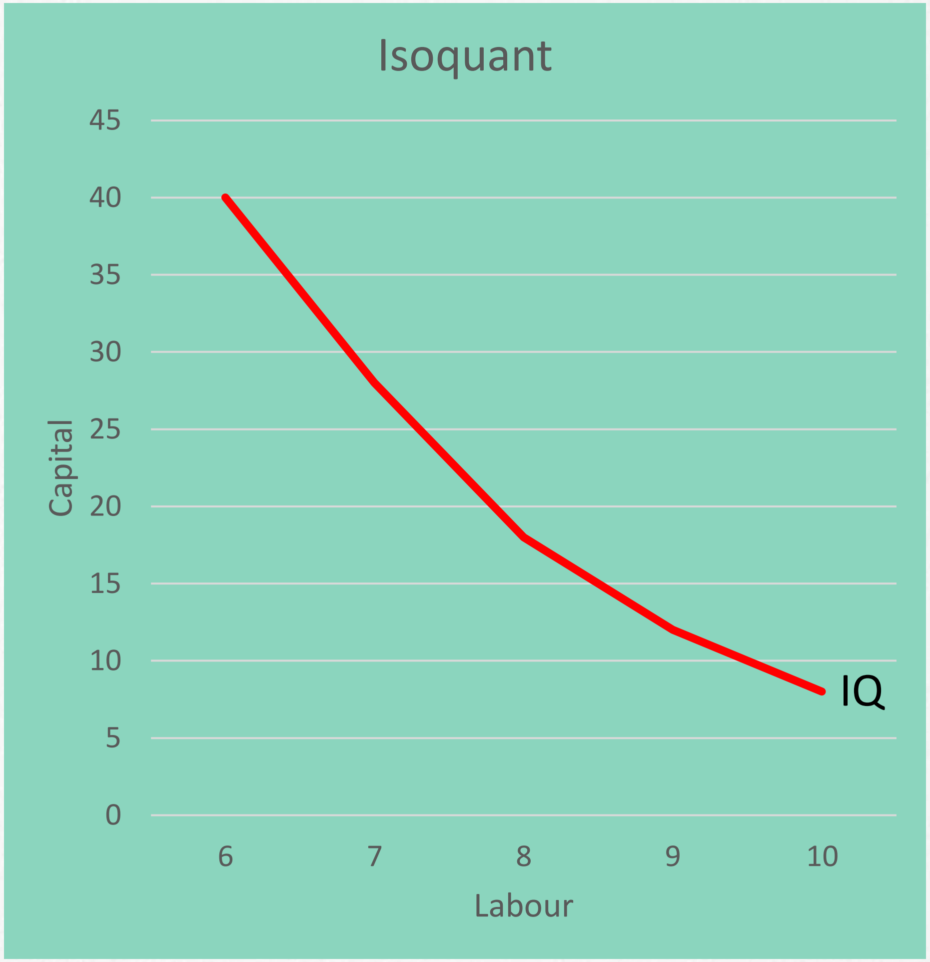
Production Function With Two Variable Inputs



Features of Isoquants

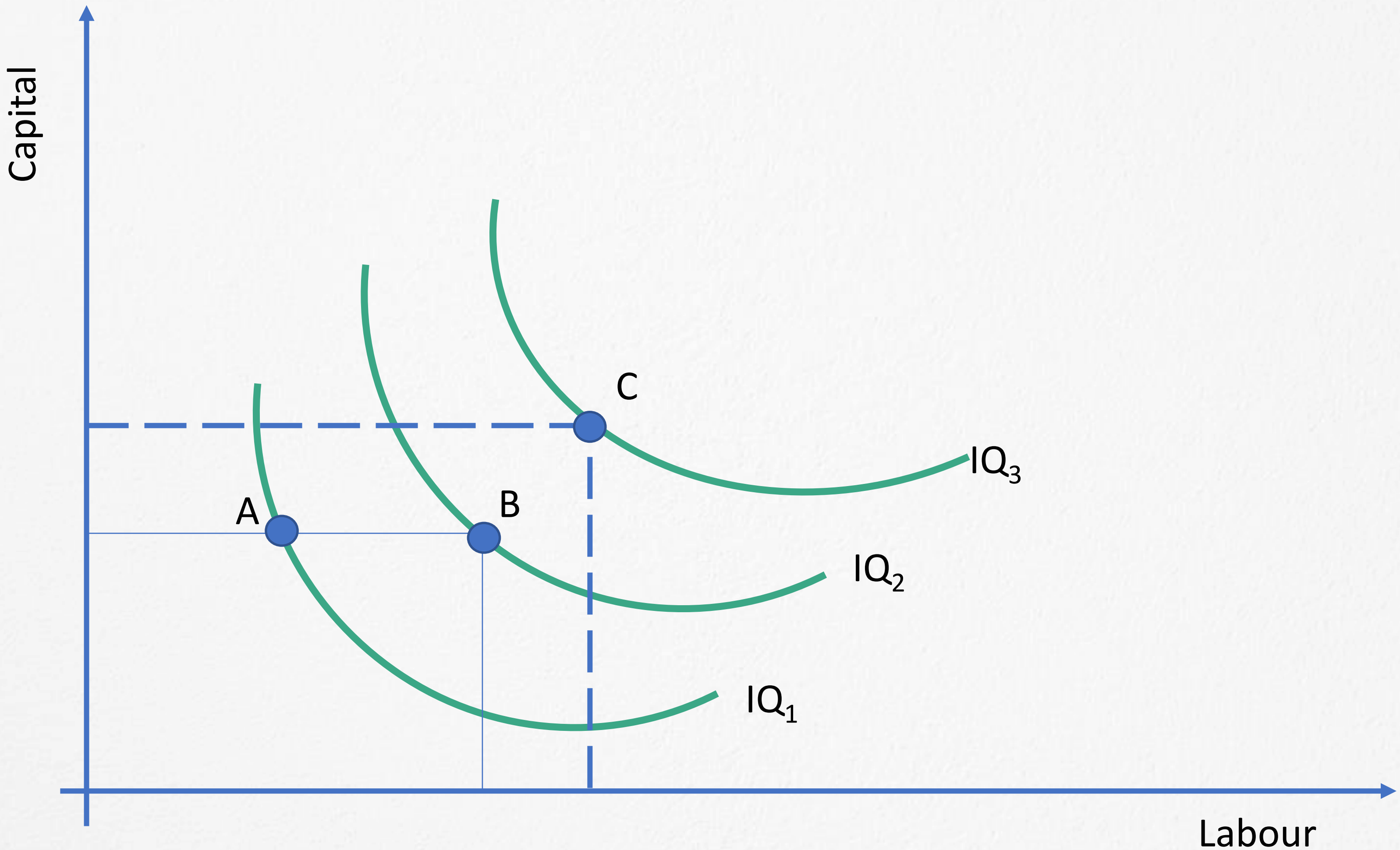
Downward Sloping

- As per the Technology Efficiency, the IQ should slope downwards.
- It implies that to produce the same level of output, one input will be used in the increasing order while the other will be used in decreasing order.
- Slope of the IQ= - $\frac{\Delta K}{\Delta L}$



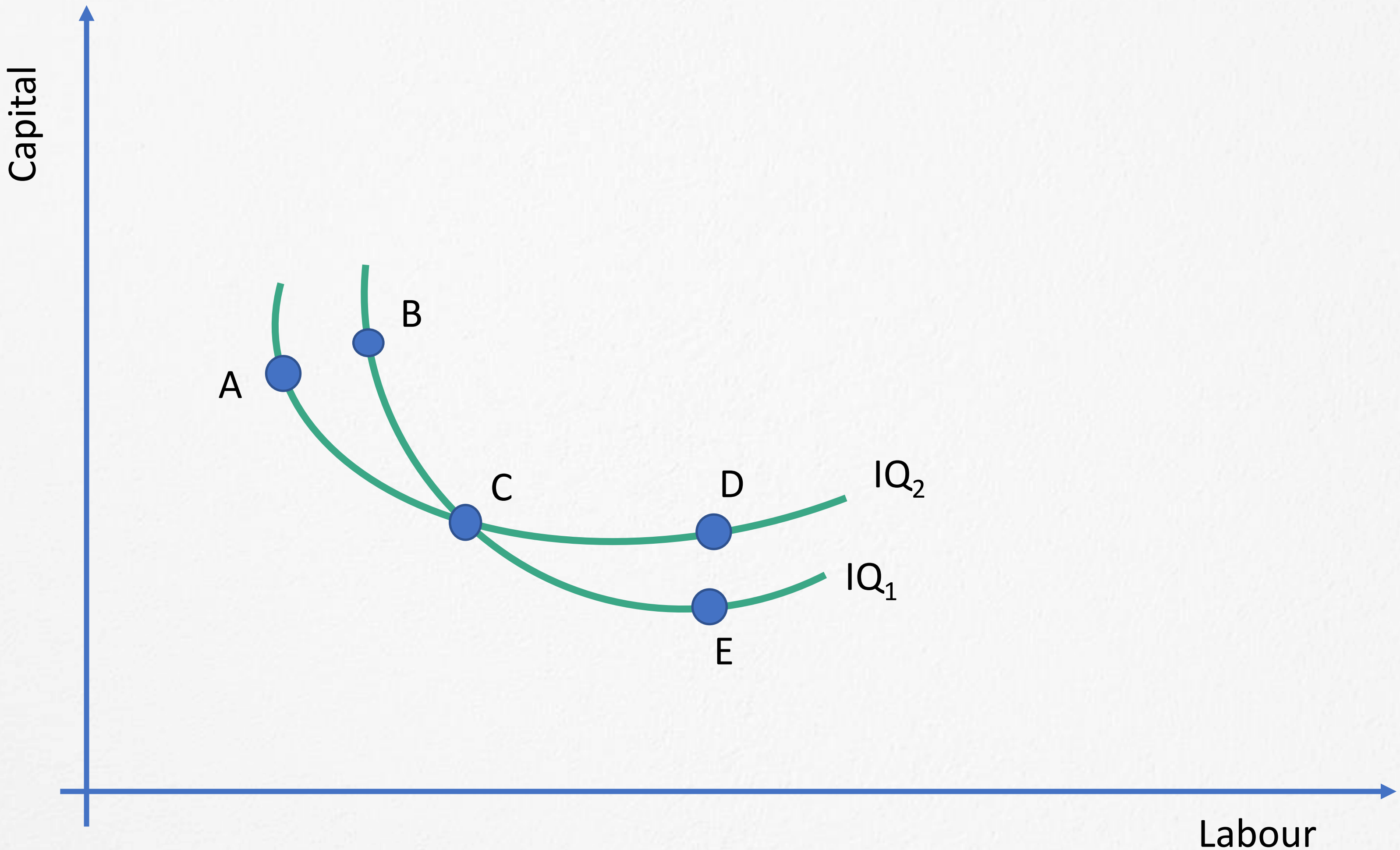
Features of Isoquants

A higher Isoquant Represents a Higher Output



Features of Isoquants

Isoquants do not intersect each other



Features of Isoquants

Convex to the Origin

- The Marginal Rate of Technical Substitution explains the convexity of the Isoquants.
- One factor substitutes the other factor but then after a point it becomes difficult to substitute the factor.

Features of Isoquants

Marginal Rate of Technical Substitution

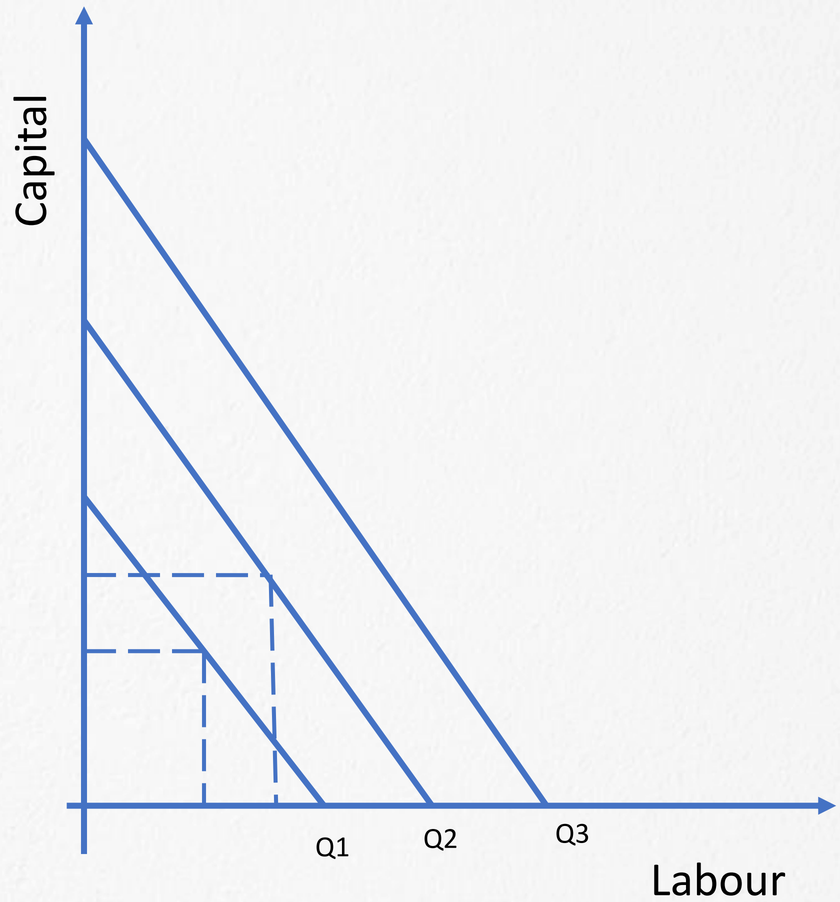
- MRTS measures the reduction in one input, due to unit increase in the other input that is just sufficient to maintain the same level of output.

$$MRTS_{LK} = -\frac{\Delta K}{\Delta L} \text{ or } MRTS_{LK} = \frac{MP_L}{MP_K}$$

Special Shapes of Isoquants

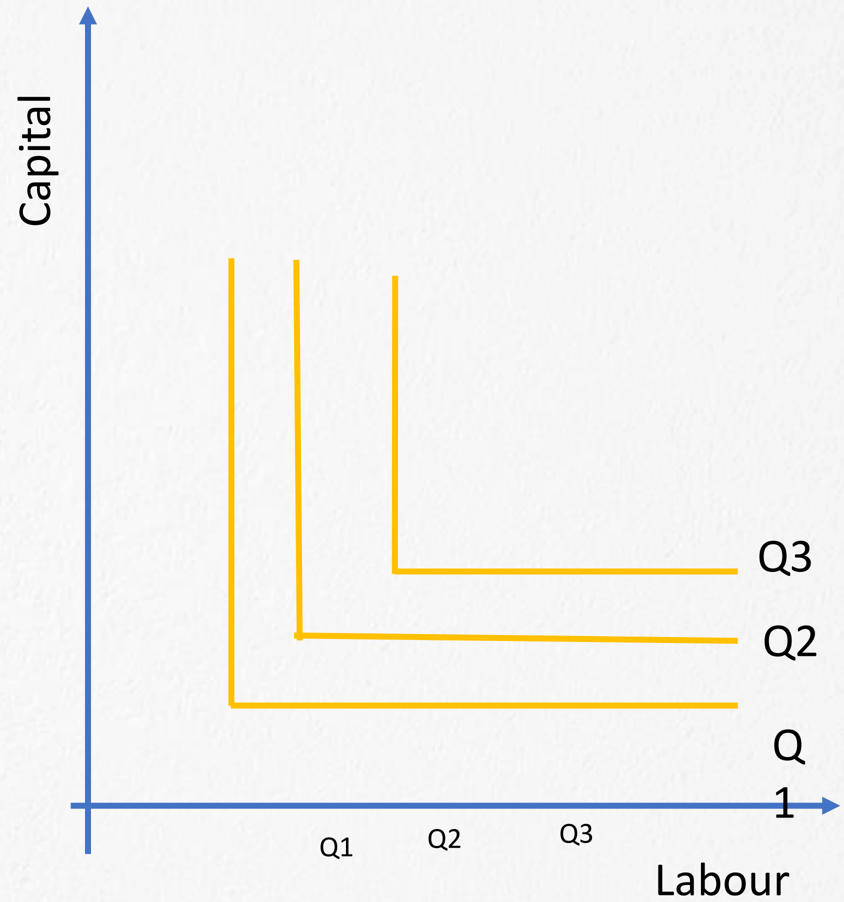
Linear Isoquants

When the factors of production are perfect substitutes of each other.



Right Angled Isoquants

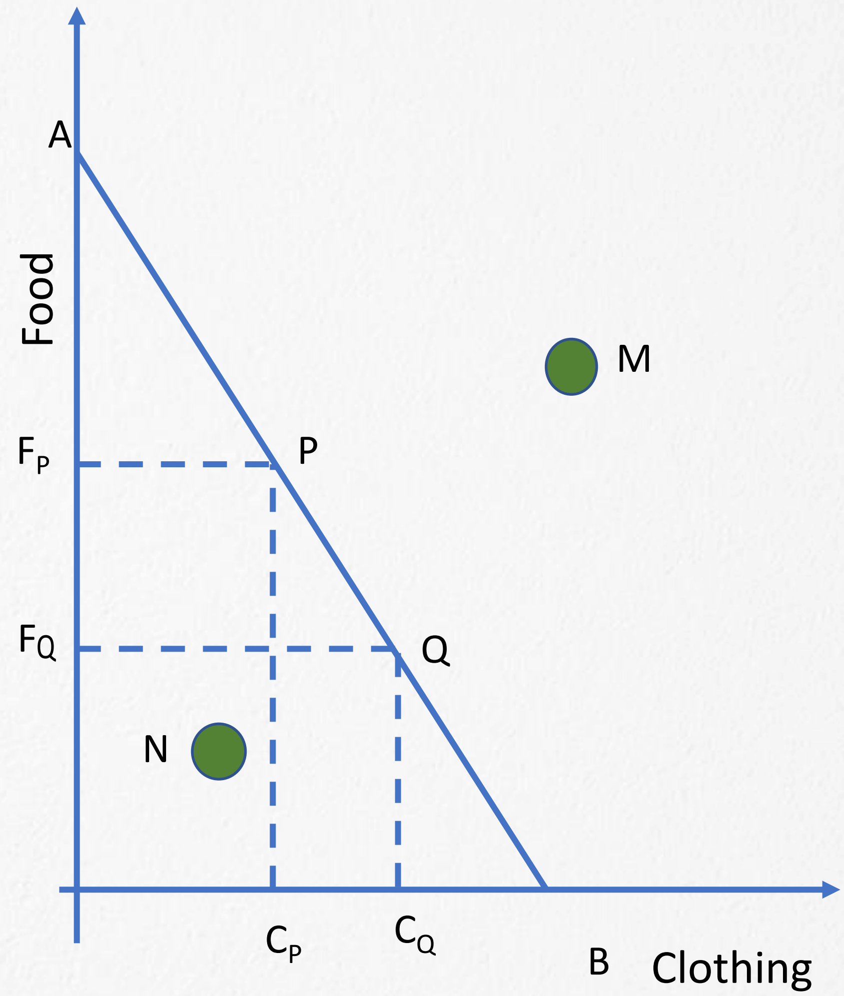
When the factors of production are perfect complements of each other.



Production Possibility Curve

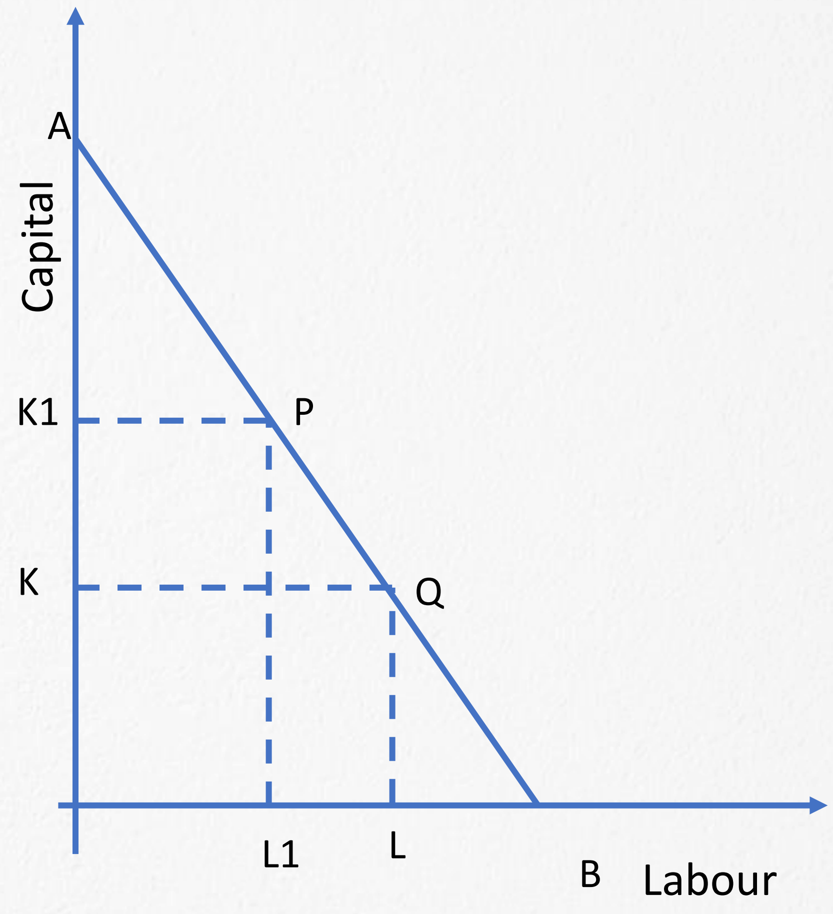
Production Possibility Curve

For an individual, PPC demonstrates the different combinations of two commodities that the individual can have, with a given income or within a given budget, and at given prices of the commodities being purchased.

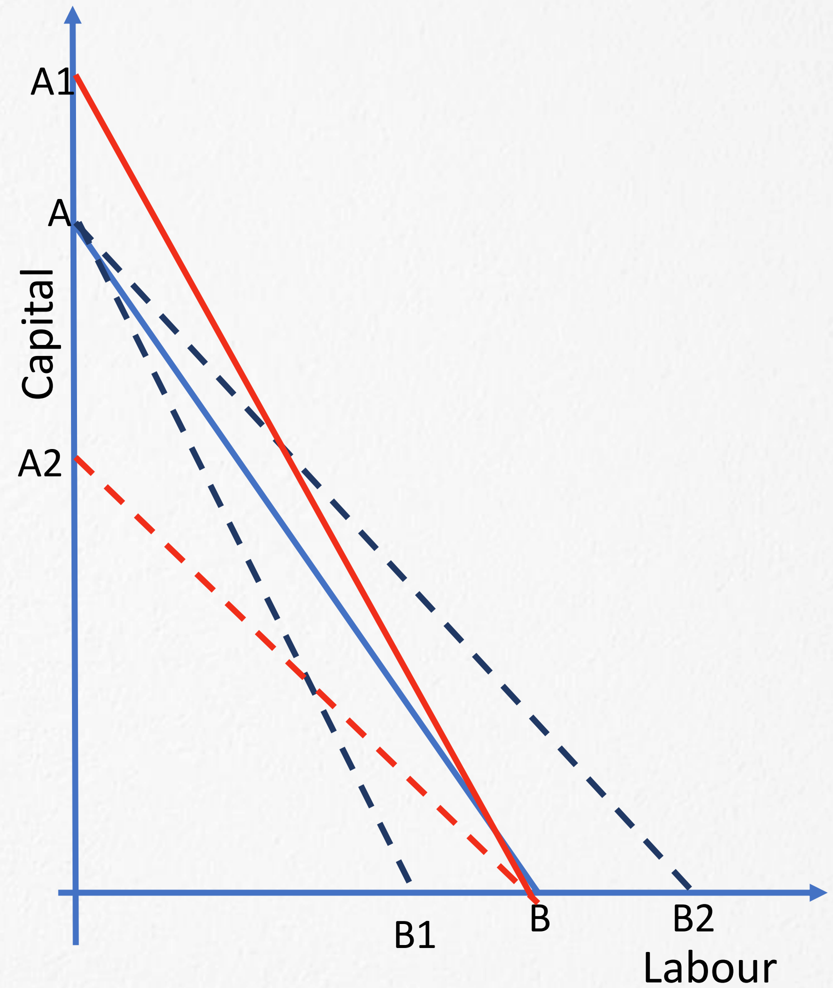


Iso-cost Lines

- The iso-cost line is the locus of points of all the different combinations of labour and
- capital that a firm can employ, given the total cost and prices of inputs.
- The slope of the Iso-cost line is given $\frac{\Delta K}{\Delta L}$



Iso-cost Lines

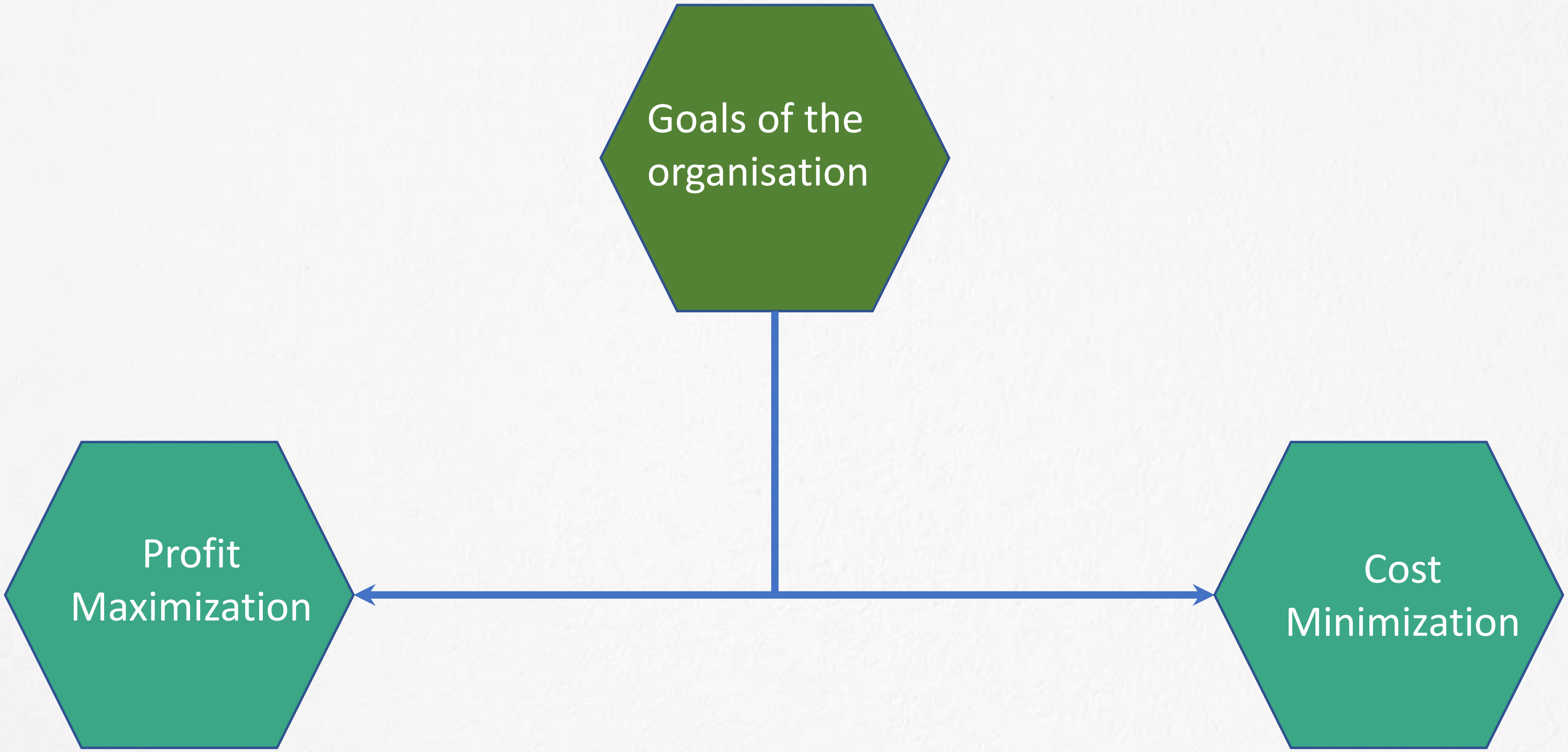


Producer’s Equilibrium

Producer's Equilibrium

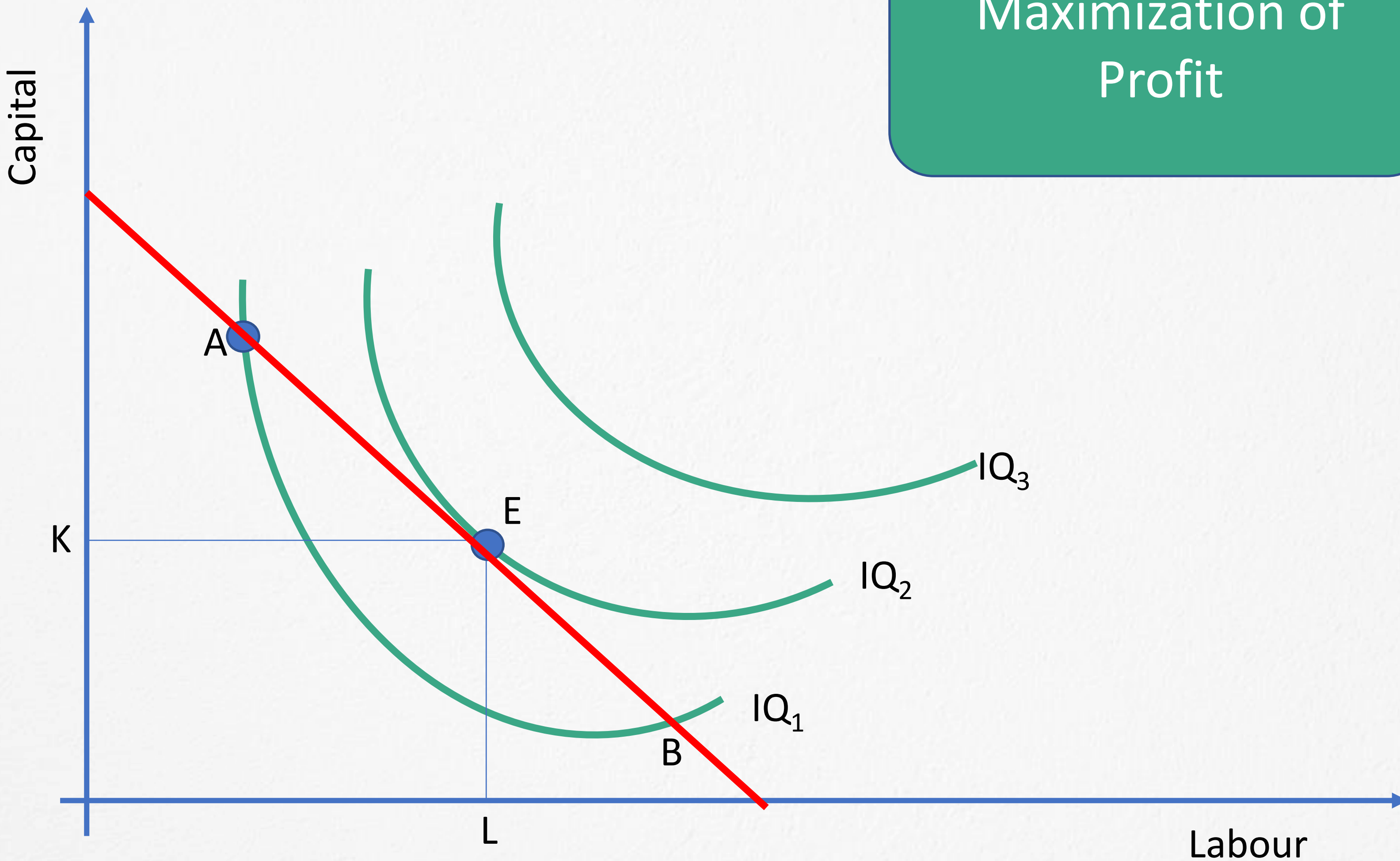
- Each Isoquant shows the technically efficient combinations of inputs.
- When a producer/firm is faced by a number of technically efficient combinations then it chooses the economically efficient combination and this becomes the equilibrium point.

Producer’s Equilibrium



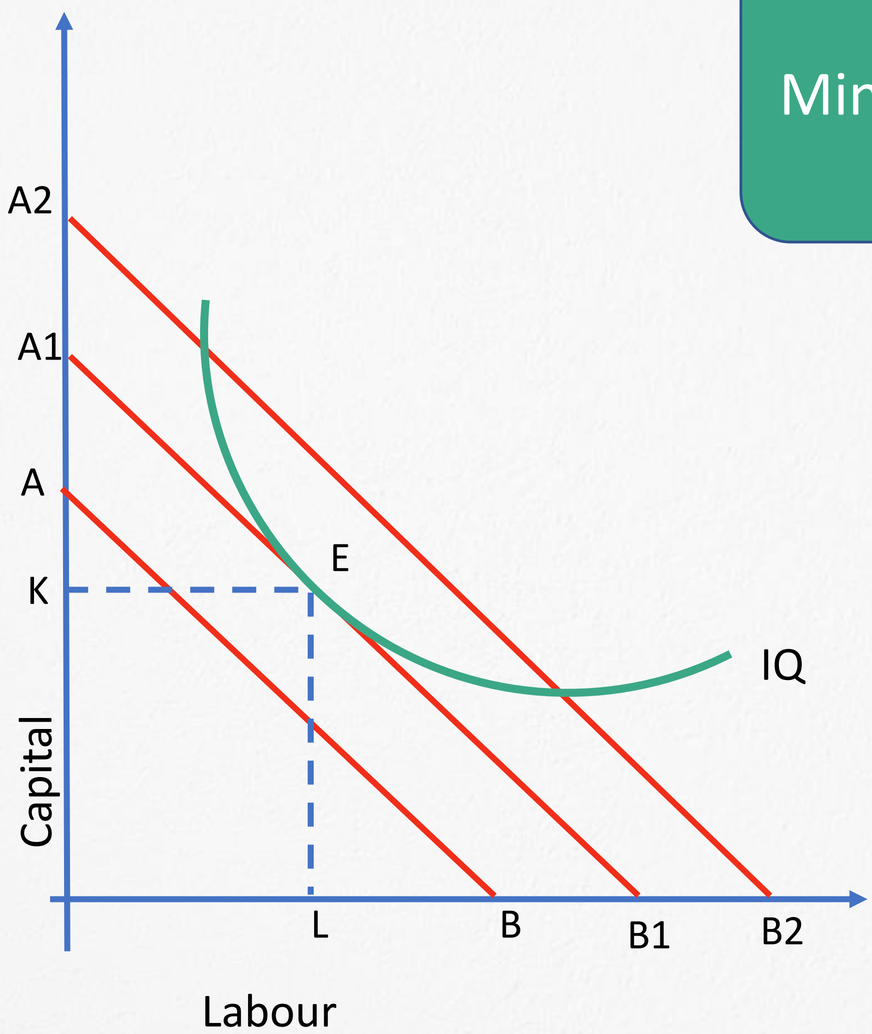
Producer's Equilibrium

Maximization of Profit

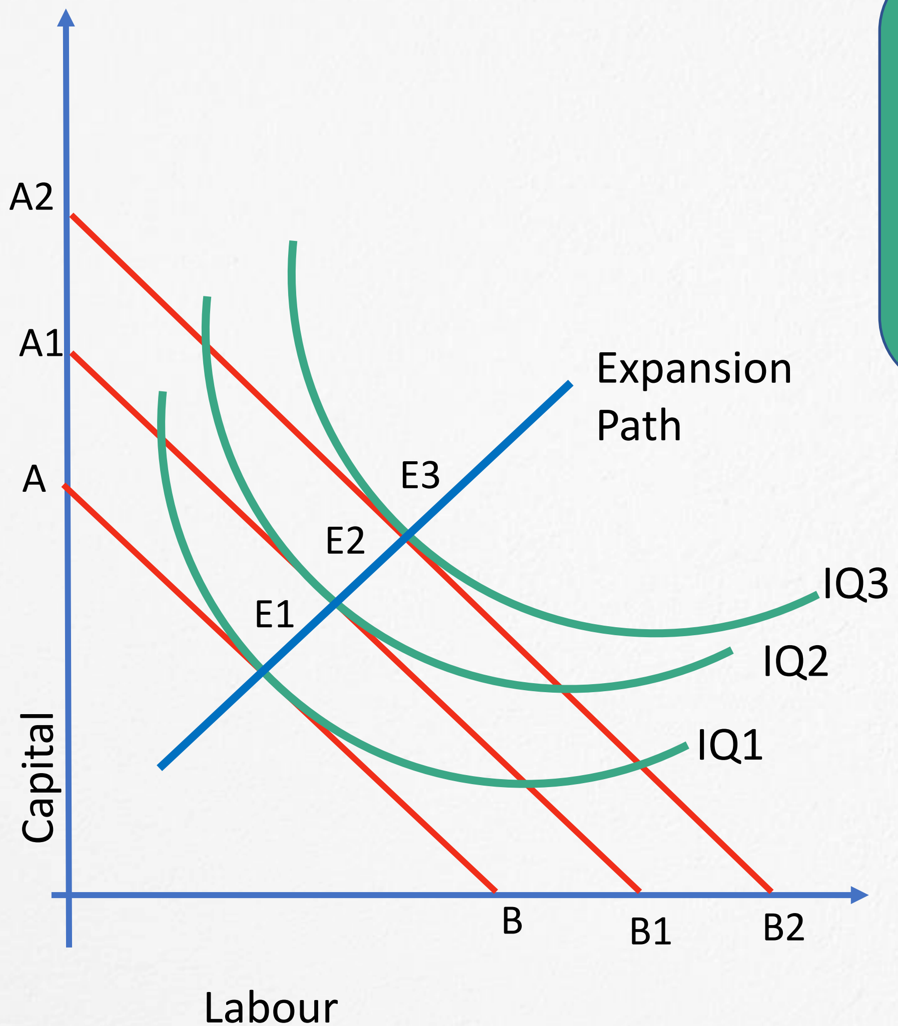


Producer's Equilibrium

Minimization of Cost



Producer’s Equilibrium

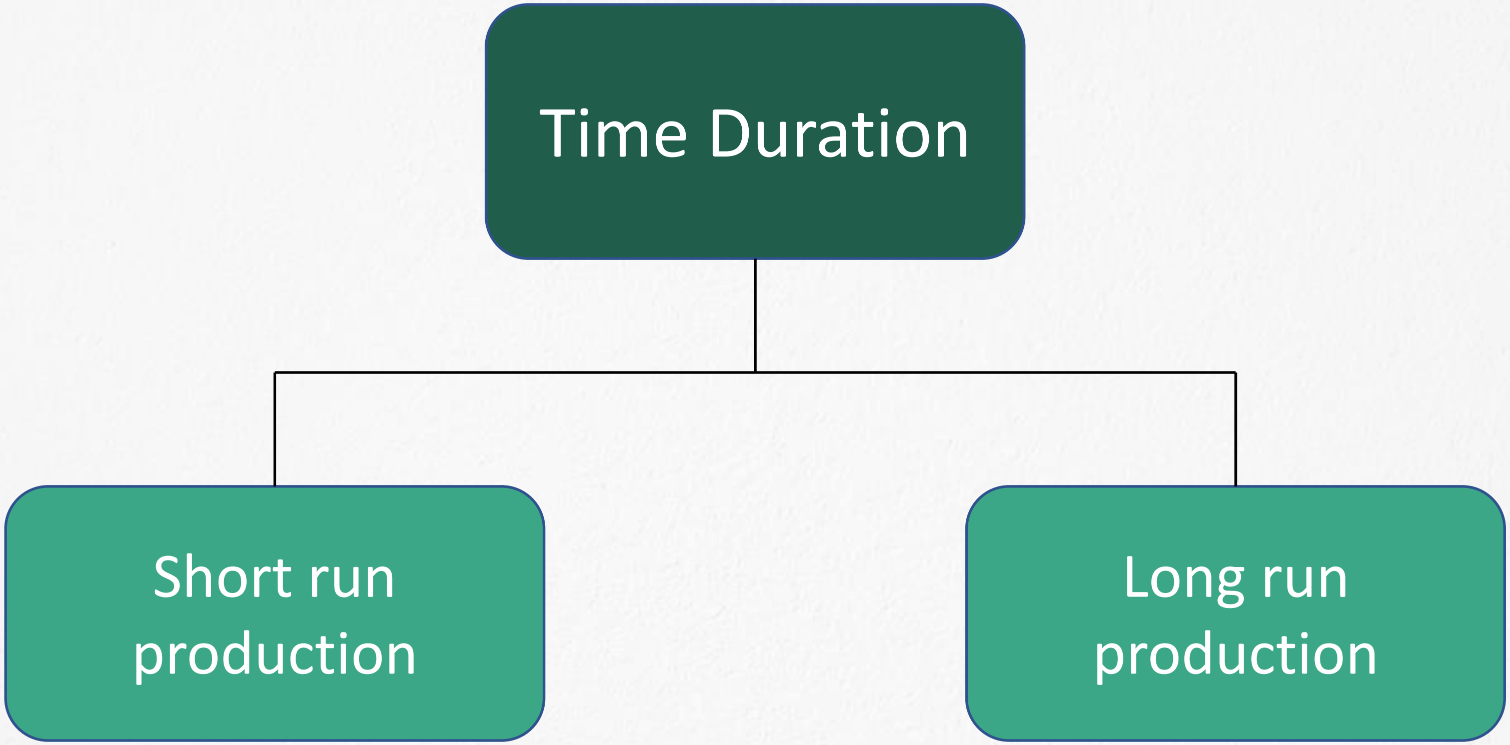


Expansion path is the line formed by joining the tangency points between various isocost lines and the corresponding highest attainable isoquants.

Introduction

- Production is the conversion of inputs into outputs by the application of the factors of production.
- There are five main factors of production namely land, labour, capital, enterprise and technology.

Production Function



Returns to Scale

"The term returns to scale refers to the changes in output as all factors change by the same proportion."

Koutsoyiannis

"Returns to scale relates to the behaviour of total output as all inputs are varied and is a long run concept".

Leibhafsky

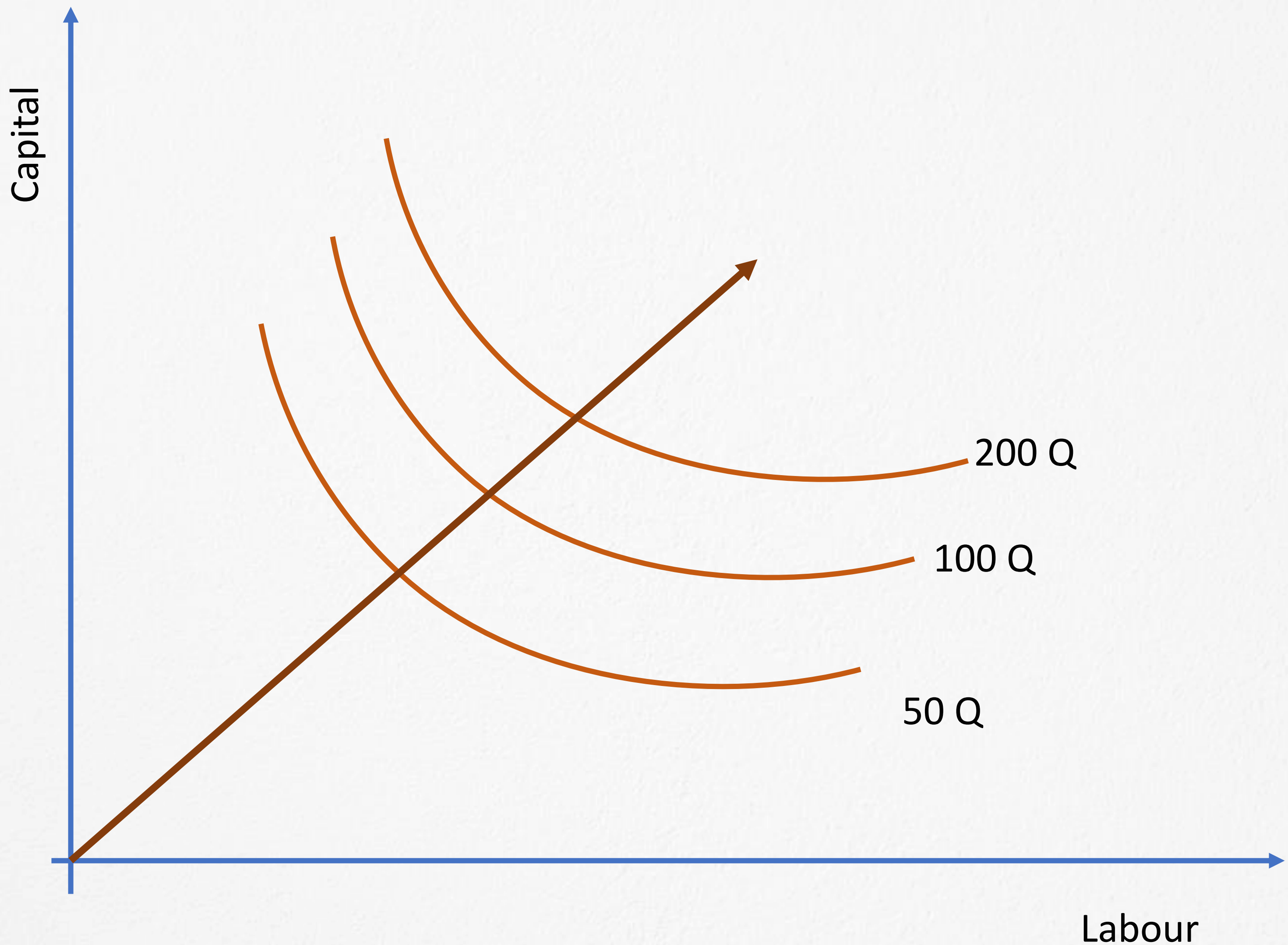
Returns to Scale

- It is a long run phenomenon.
- All the factors of production are variable.
- The rate of change in the factors is constant.
- There can be three possible outcomes
  1. Constant Returns
  2. Increasing Returns
  3. Decreasing Returns

Constant Returns to Scale

- It happens when a proportional increase in inputs lead to proportional increase in output.
- If labour and capital are doubled and the output also doubles, there is constant returns to scale.
- The Cobb-Douglas production function is a good example of constant returns to scale.

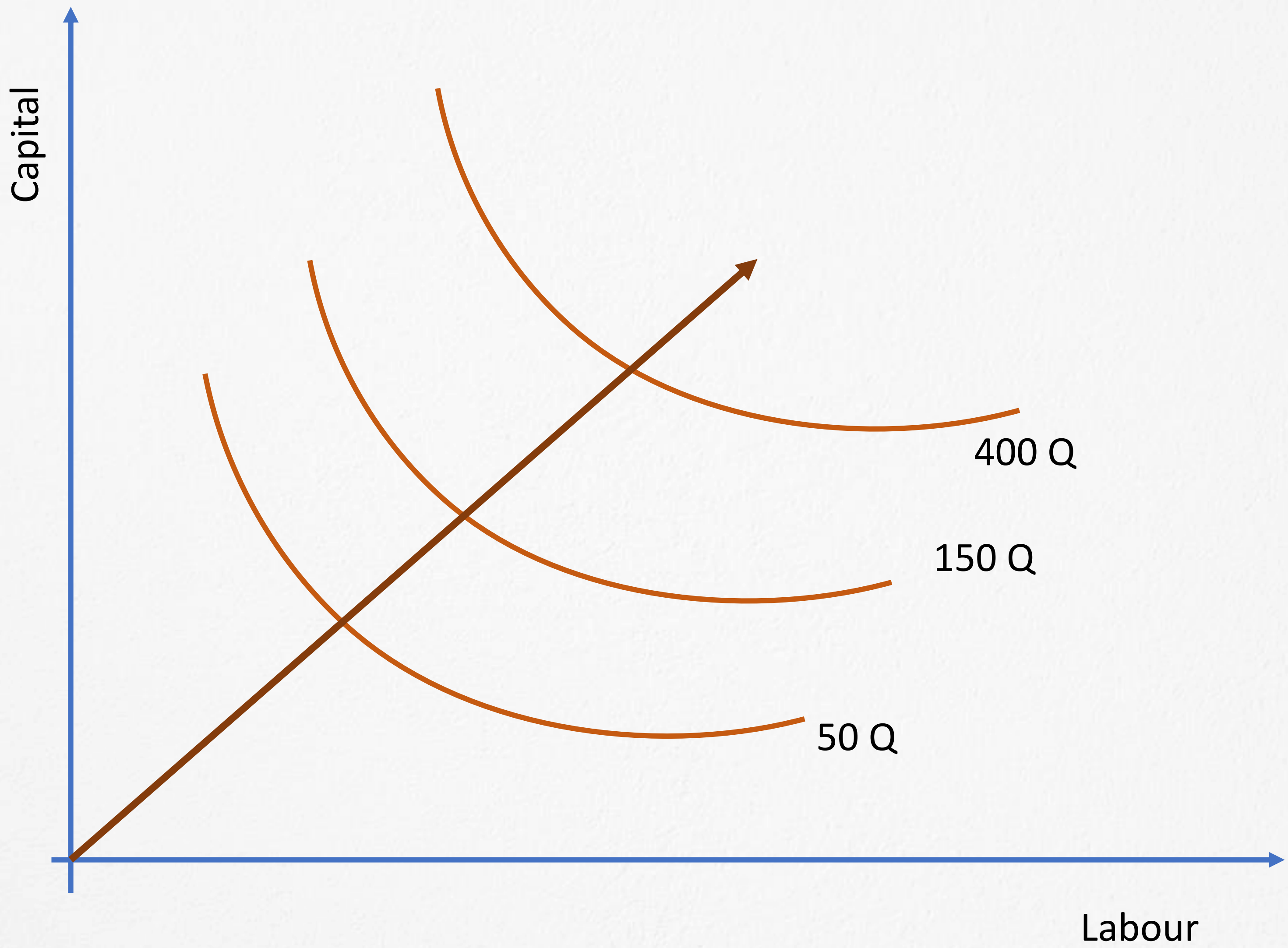
Constant Returns to Scale



Increasing Returns to Scale

- It happens when a proportional increase in inputs lead to more than proportional increase in output.
- If labour and capital are doubled and the output increases more then double, there is increasing returns to scale.

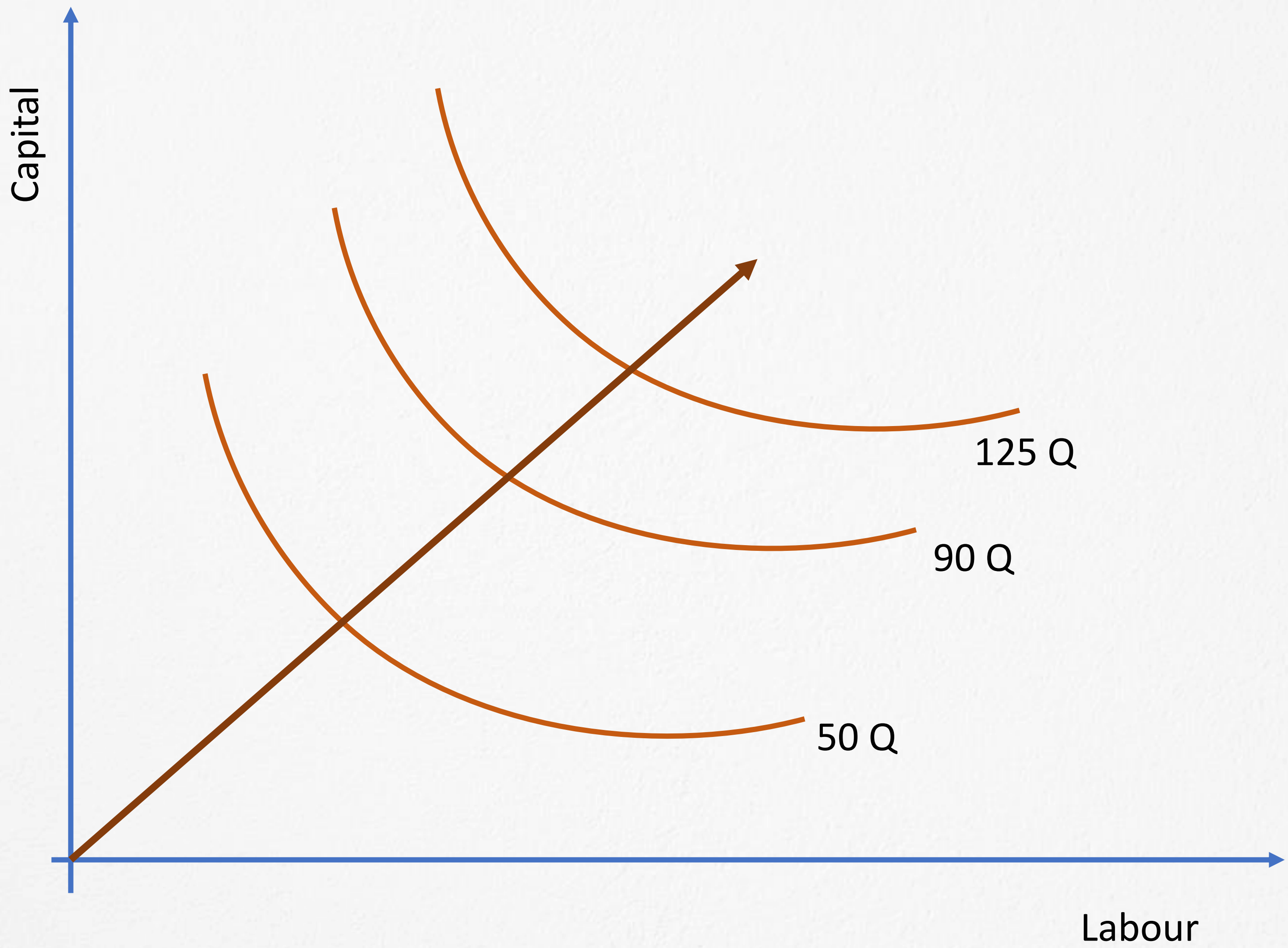
Increasing Returns to Scale



Decreasing Returns to Scale

- It happens when a proportional increase in inputs lead to less than proportional increase in output.
- If labour and capital are doubled and the output increases less then double, there is decreasing returns to scale.

Decreasing Returns to Scale



Impact of Returns to Scale

The nature of the returns to scale affects the **shape** of a business's **average cost curve –**when there are sizeable increasing returns to scale, and then we expect to see economies of scale from long run expansion.