Unit - 3

Production and Cost

↳ refers to transformation of inputs into outputs.

- **Production Function** : an expression of the technological relation between physical inputs and outputs of a good.

Short Run	Long Run
→ a period in which output can be changed by changing only variable factors.	→ a period in which output can be changed by changing all factors of production.
→ Fixed ~~wants~~ inputs like plant, machinery, etc cannot be changed	→ It is long enough for the firm to adjust all its inputs according to change in the conditions in the long run
→ Some factors are fixed and some are variable and fixed factors cannot be changed during a short span of time.	→ firm can change its factory size, switch to new techniques of production, etc.
→ Price determination → demand is more active in p.d as supply cannot be increased immediately with increase in demand.	→ Both demand and supply play equal role in price determination as both can be increased.

Law of DM productivity states that if more variable input units are used along with a certain amount of fixed inputs, the overall output might grow at a faster rate initially, then at steady rate and finally at declining rate.

	Variable factors	Fixed factors
Meaning	Refers to those factors which can be changed in the short run.	• Refers to those factors, which cannot be changed in the short run.
Relation with output	They vary directly with output	• They do not vary directly with the level of output.
Example	Raw material, casual labour.	• Plant, machinery, etc.

Types of Production Function

$Q_c = f(L, \bar{K})$

↳ Short Run Production Function = (where output is increased by changing only one input while keeping other inputs changed.

- (Variable Proportion Type)
- As there is change in variable input only, the ratio between different inputs tends to change at different levels of output

→ Long Run Production Function = (when output is increased by increasing all the ~~outputs~~ inputs simultaneously and in the same proportion.

- (Constant Proportion Type)
- As all inputs are variable in the long run, the ratio between different inputs tends to remain same at different levels of output.

Product

(refers to the volume of goods ~~purchased~~ produced by a firm or an industry during a specific period of time)

- Total product (TP)
- Marginal product (MP)
- Average product (AP)

Types of Product

1) **Total Product** - refers to total quantity of goods produced by a firm during a given period of time with given number of inputs.

- For ex :- If 10 labours produce 60 kg of rice, then total product is 60kg.

2) **Average Product** - refers to output per unit of variable input.

- For ex : If TP is 60 kg of rice, produced by 10 labours, then average product will be 6kg.

3) **Marginal Product** - refers to addition to total product, when one more unit of variable factor is employed.

- For example :- If 10 labours make 60kg of rice and 11 labours make 67 kg of rice, then MP of 11th labour will be 7kg.

★ Producer and Optimal Production Choice

Optimizing behaviour in short run.

⇒ Types of Inputs
- Fixed (land, capital)
- Variable (labour)

⇒ Time period
- Short run (Capital remains constant) (only labour is changed) (One factor is variable i.e. labour)
- Long run (Both factors are variable)

★ Law of diminishing marginal productivity is applicable in the short run.

★ Production with One Variable Input (Labour)

When capital is fixed but labour is variable, the only way the firm can produce more output is by increasing its labour input.

For example; Imagine that you manage a clothing factory. Although you have fixed equipment, you can hire more or less labour.

* There are two types of product :-

i) Average Product = $\frac{\text{Output per unit of a particular input}}{}$

=> It measures the productivity of the firm's workforce in terms of how much output each worker produces on average.

=> $\frac{q}{L}$

ii) Marginal Product = Additional output produced as an input is increased by one unit.

=> $\frac{\Delta q}{\Delta L}$

(L) Amount of Labour	Amount of Capital	(q) Total Output	(q/L) Average Product	($\Delta q/\Delta L$) Marginal Product
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 Saturation Point	16	4
8	10	112	14	0
9	10	108	12	-4

* Slopes of the Product curves

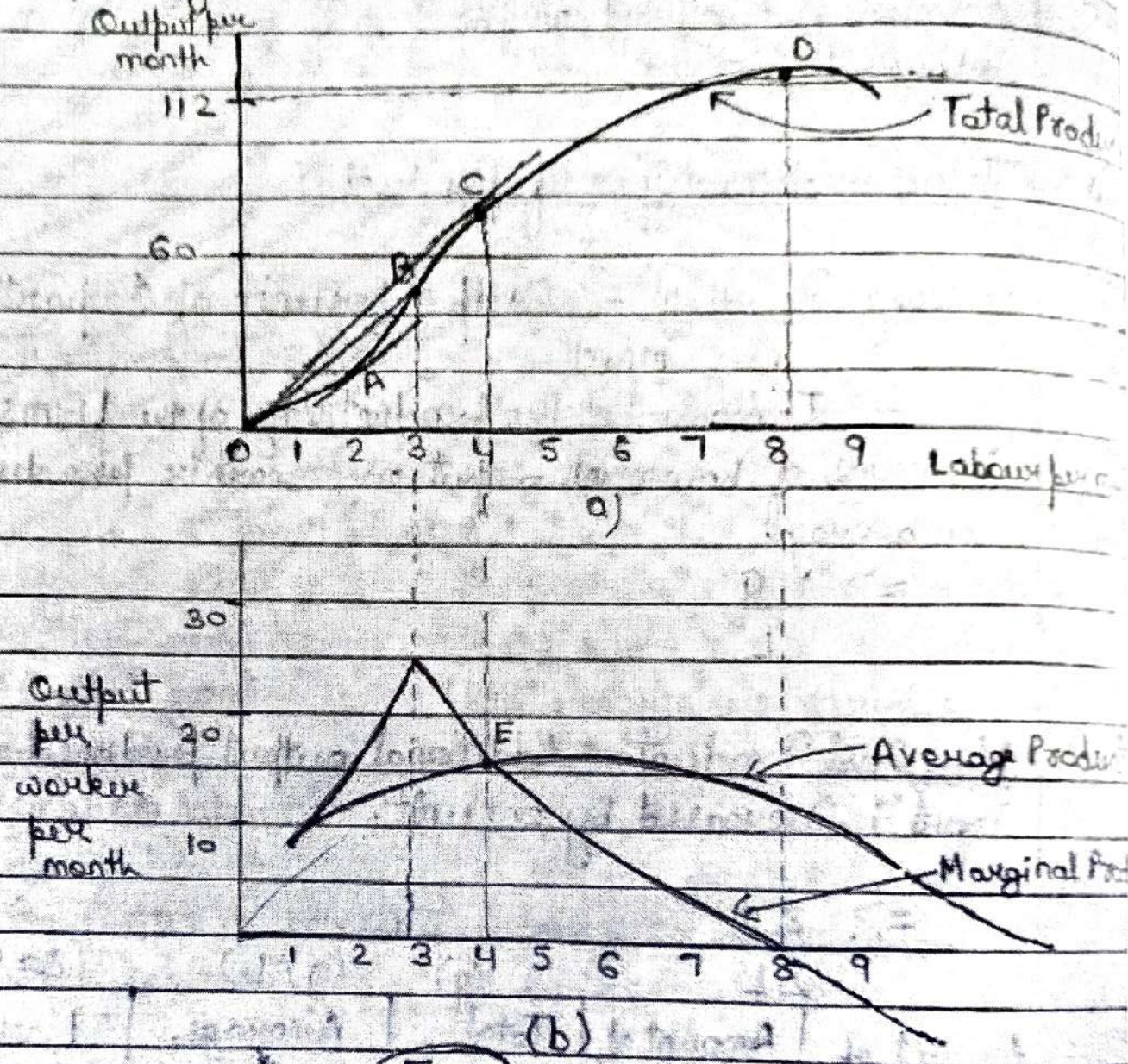


Fig 1

(a) shows that as labour is increased, output increases until it reaches the maximum output of 112; thereafter it falls.

(b) shows average and marginal product curves. Marginal product is positive as long as output is increasing but becomes negative when output is decreasing. At point (A), the marginal product is 20 because the tangent to the total product curve has a slope of 20.

=> In the table, 112 is the highest point of output after this fixed capital gets exhausted

-> Relationship b/w inputs and outputs is called production function.

From the curve, we can determine the relationship b/w MP and AP.

- When AP ↑, then MP is above AP
- Point of intersection when AP is maximum
- When AP ↓, then MP is below AP

Law of Diminishing Marginal Returns.

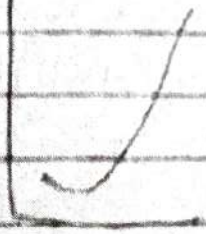
- Principle that as the use of an input increases with other inputs fixed, the resulting additions to output will eventually decrease.
- Usually applies in the short run but can also apply in the long run. In long run, a manager may still want to analyze production choices for which one or more inputs are unchanged.
- describes a declining marginal product but not necessarily a negative one.

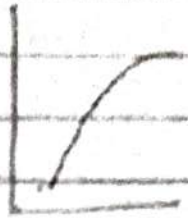
Assumptions:

-> Technology is given
-> Labour is homogenous
-> Capital is constant

Types of Increasing Rate

5		5		5	
10		6		10	
15		9		14	
20		14		17	





Constantly increasing

Increasing at increasing rate

Increasing at decreasing rate

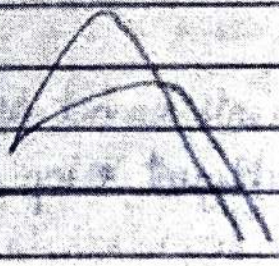
Relation between TP and MP

1. $TP\uparrow\uparrow$, $MP\uparrow$
2. $TP\uparrow\downarrow$, $MP\downarrow$
3. TP_{max}, MP_0
4. $TP\downarrow$, MP (negative
5. $TP = \Sigma MP$
6. $MP = \frac{\Delta TP}{\Delta Q}$

Relation between AP and MP

1. $AP\uparrow$, $MP > AP$
2. AP_{max}, $AP = MP$
3. $AP\downarrow$, $MP < AP$

AP and MP



★ Law of diminishing Marginal Returns = states the general tendency for the marginal product of an input to eventually decline as its use is increased holding all other inputs fixed.

Three stages of production

1. Increasing stage
2. Constant stage
3. Decreasing stage

Acc to Fig 1. To the left of point E the marginal product rises, reaches maximum and then falls as diminishing returns set in while the average product rises and reaches its maximum. This is called stage I. i.e Increasing Marginal Returns stage.

Stage II Ranges from 4 to 8 labour units i.e to the right of E and upto the point where MP is zero.
(Decreasing Marginal returns stage)

Stage III occurs when MP is negative (i.e when more than 8 labour units are employed in our example.
(Negative marginal returns stage)

★ A rational producer would never operate in stages I and III

In stage I producer will produce till MP is not decreasing but positive or MP > AP

When MP is max is P.I. of Inflexion/Inflection

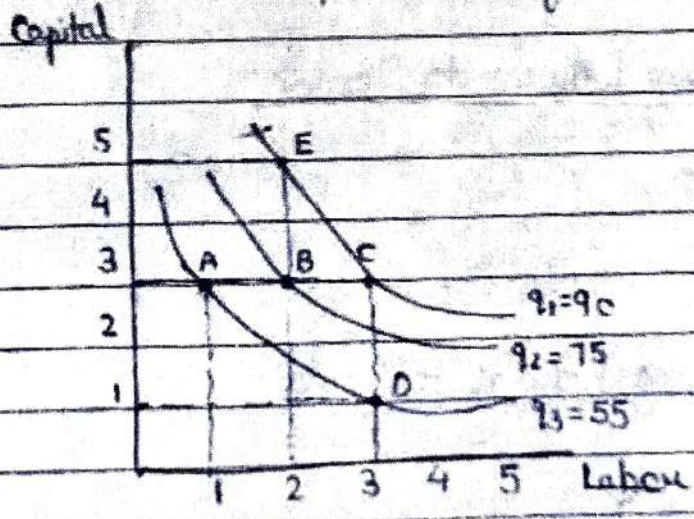
Production with Two Variable Inputs (Long Run)

- **Isoquant**

Capital Input	Labour Input				
	1	2	3	4	5
1	20	40	55	65	(75)
2	40	60	(75)	85	90
3	55	(75)	90	100	105
4	65	85	100	110	115
5	(75)	90	105	115	120

Along the Row We can see Output ↑ as labour input ↑, capital remains fixed.
Down the column, Output ↑ as Capital inputs ↑

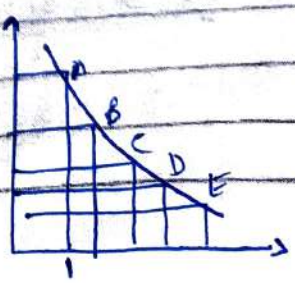
Isoquant Map Graph combining a number of isoquants, used to describe a production function.



Isoquant

Isoquant

	Capital	Labour	Output	MRTS $=-\frac{\Delta L}{\Delta K}$
A	1	12	100	—
B	2	8	100	$-(-4/1)=1$
C	3	5	100	$-(-3/1)=3$
D	4	3	100	$-(-2/1)=2$
E	5	2	100	$-(-1/1)=1$



higher the Isoquent higher the productivity

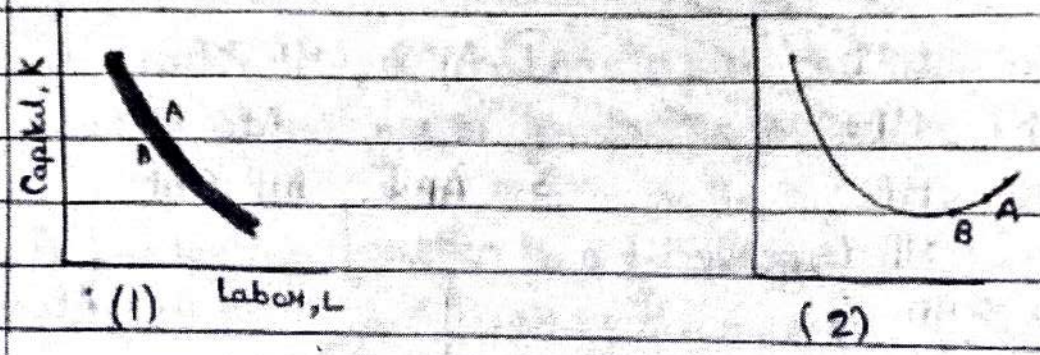
Isoquant : shows various combination of 2 factor who provides same level of output to its producer.

The Productive Inputs Principle : Increasing the amounts of all inputs strictly increases the amount of output the firm can produce

It implies that isoquants and families of isoquants have several properties :-

convex to origin

1 Isoquants cannot be thick because then there would be two input combinations on the same Isoquant

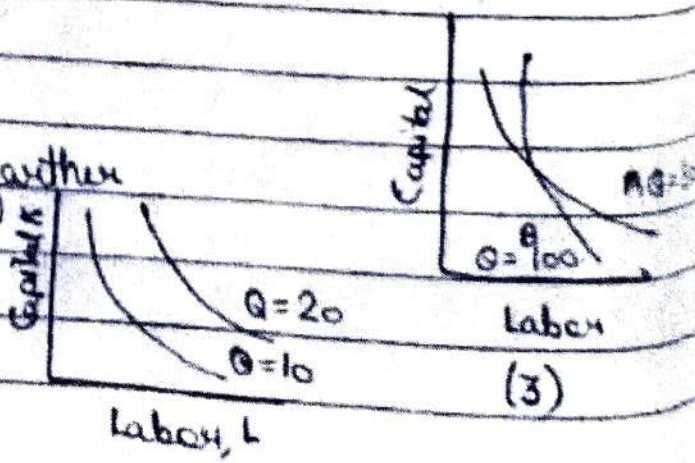


2 Isoquants cannot slope upward. because then there would be two different input combinations on the isoquant.

3 An isoquant is the boundary between input combinations that produce more and less than a given amount of input.

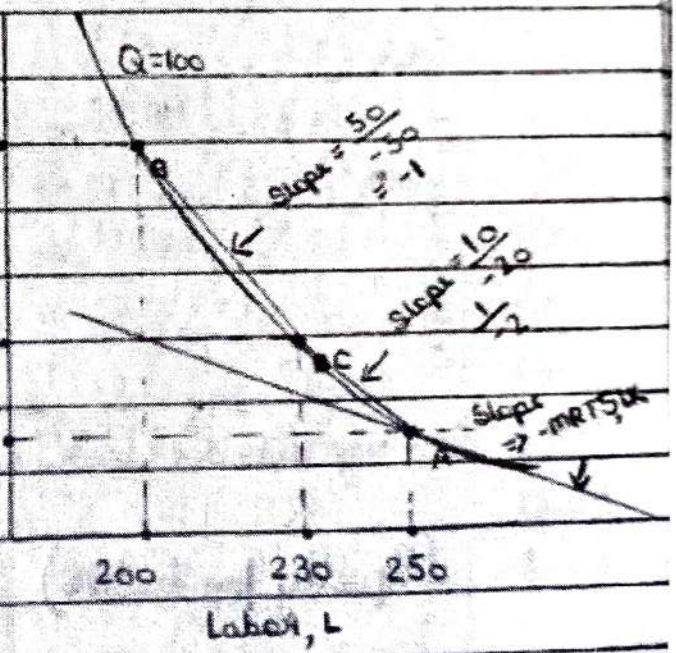
4 Isoquants cannot cross

5) Higher level isoquants lie farther from the origin.



The marginal rate of technical substitution (MRTS) for input X with input Y, written as $MRTS_{XY}$, is the rate $\left(-\frac{\Delta Y}{\Delta X}\right)$ at which a firm must replace units of X with units of Y to keep output unchanged starting at a given input combination, when the changes involved are tiny. (It equals the slope of the firm's isoquant at this input combination, times negative one.) $MRTS = \frac{\Delta L}{\Delta K} = -(\text{slope of firm's isoquant})$

Forex If we start at input combination A, and reduce labor by 50 hours, to 50 moving to point B, we must add 50 hours of machine time to keep the output unchanged.

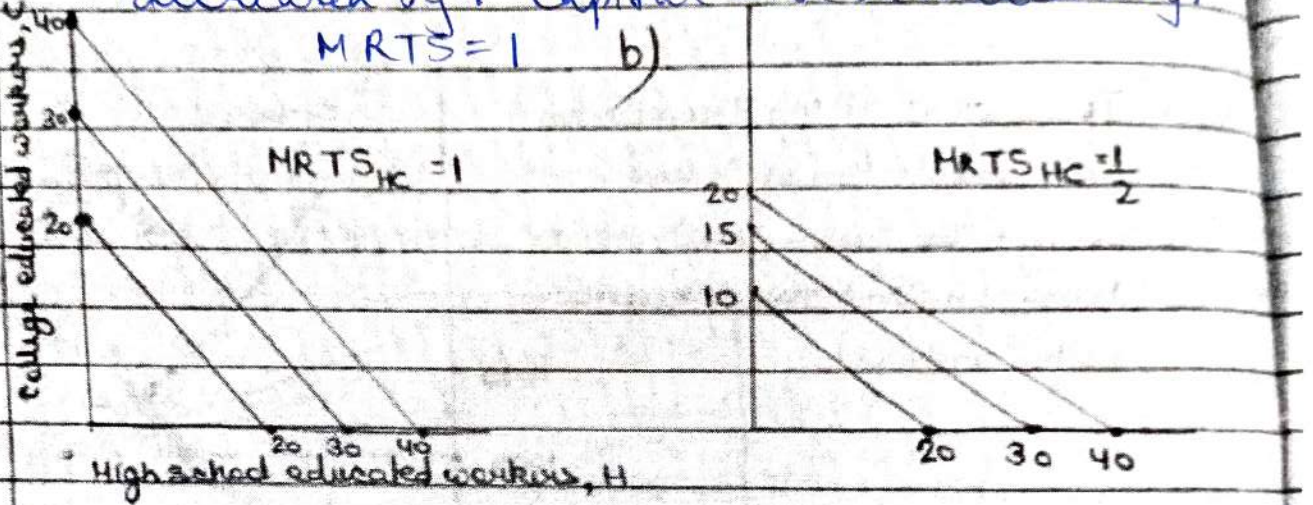


★ An isoquant for a production process using two inputs X and Y has a declining marginal rate of technical substitution if $MRTS_{XY}$ declines as we move along the isoquant, increasing input X and decreasing input Y.

Input Substitution for Three Special Production Technologies

1) Perfect substitutes = Two inputs are perfect substitutes if their functions are identical, so that a firm can exchange one for another at a fixed rate. Here if labour is decreased by 1 Capital will be increased by 1

a) MRTS = 1 b)



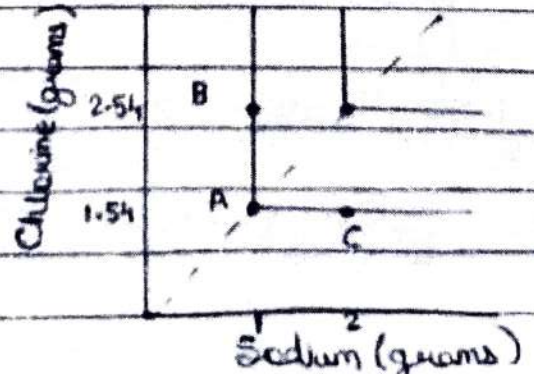
(Equally productive)

(CEW are twice as productive as a HSW)

In both cases MRTS$_{HC}$ is the same, regardless of the cost of the inputs the firm uses

2 Perfect complement (Fixed Proportions) = Two inputs are used in fixed proportions when they must be combined in a fixed ratio. Then they are known as perfect complements.

Capital and labour are dependent to an extent



The dashed line from the origin represents the input combinations in which sodium and chlorine are combined in a 1:1:54 ratio. Adding only one more chlorine (A) and then moving to point B & C as only more sodium does not yield more salt

In this case one can't be ↑ or ↓ for another and if only one input is ↑ or ↓ productivity will have no effect as they both are compliments. Here MRTS = ∞ or 0

$\left(\frac{TP}{L}\right)$

L	K	Total Product	AP
1	1	100	100
2	2	250	125
3	3	450	150
4	4	760	190
5	5	950	190
6	6	1140	190
7	7	1260	180
8	8	1280	160

★ **Returns to Scale**

~~If states~~ If given a certain combination of factors of production, producing a given of output

1 A firm has constant returns to scale if a proportional change in all inputs produces the same proportional change in output. 1L+1K=100
2L+2K=200

2 A firm has increasing returns to scale if a proportional change in all inputs produces a more than proportional change in output. 1L+1K=100
2L+2K=250

3 A firm has decreasing returns to scale if a proportional change in all inputs produces a less than proportional change in output. 1L+1K=100
1L+2K=150

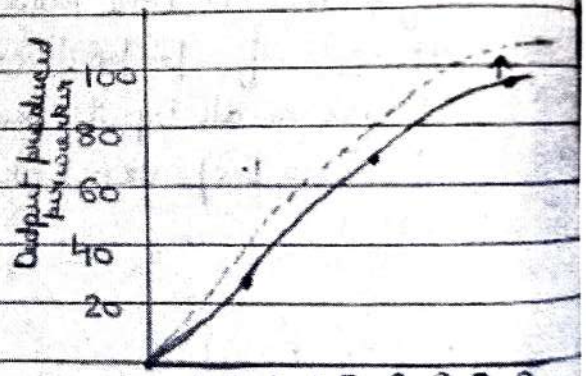
Return to scale refers to the change in output as all factors change by the same proportion

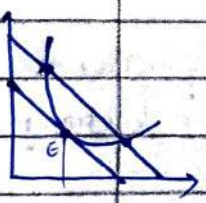
★ Increasing returns to scale arise because of the specialization of inputs as well as certain ~~fgs~~ physical laws. The reasons we observe decreasing returns to scale are more elusive. They include the presence of implicity fixed inputs, and bureaucratic costs.

★ Technological change occurs when a firm's ability to turn inputs into outputs changes over time.

Δ A firm ~~has more~~ is more productive or has higher productivity when it can ~~produce~~ produce more output using the same amounts of inputs. Equivalently, its production function shifts upward at each combination of inputs.

• Dotted technology is more productive as it results in more output at every positive level of input





At tangent the cost of production is least

Slope of Isocost line = $\frac{w}{r}$ = $MRTS_{LK}$

Δ A factor neutral technical change has no effect on MRTS at any input combination. It simply changes the output level associated with each of the firm's isoquants.

Isocost line : It represents the maximum cost a producer can incur for production. On this line cost remains same.

• $1K = ₹10$ (rental = r of interest) $1L = ₹5$ (wages = w) $C = ₹60$ (cost = C)

$C = w \times L + rK$ (labour units, Cap units)

Slope = $\frac{w}{r}$

Capital = $\frac{60}{10}$ (when w = 0) = C/r

Wages = $\frac{60}{5} = 12$ (when r = 0) = C/w

Ques Law of variable proportion

OR

Returns to factor outlinging the different stages of labour/production

Ans This law examines the production function assuming one factor as variable and others as fixed. Acc to the law, if units of a variable factor are added keeping the quantities of fixed factors constant, then beyond a certain point, additions to the total product shall go on diminishing.

This law is called as law of variable proportion because by using every additional unit of a variable factor, the factor proportion between fixed and variable factor varies

★.

Units of land	Units of labour	TP	AP	MP	Stages of Production
10 Acres	0	—	—	—	
"	1	20	20	20	1st stage
"	2	50	25	30	
"	3	90	30	40	
"	4	120	30	30	2nd stage
"	5	140	28	20	
"	6	150	25	10	
"	7	150	21.4	0	3rd stage
"	8	140	17.5	-10	

Cost theory

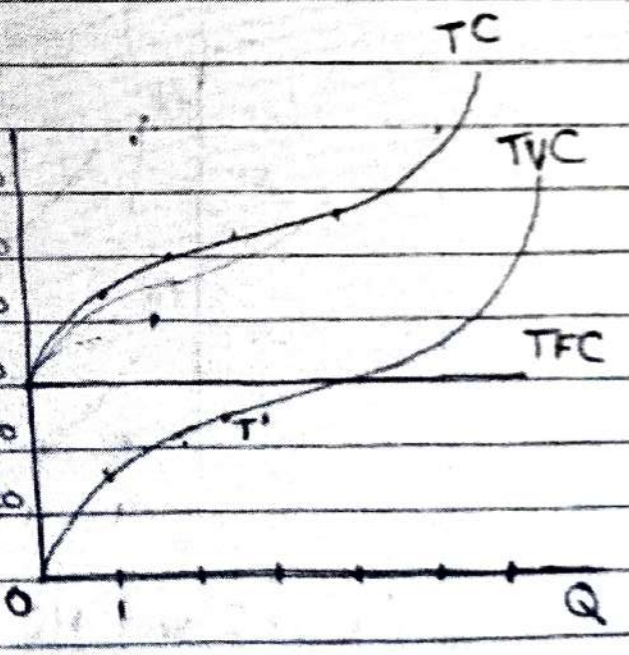
* Short run total cost curves

* Traditional theory of cost analyses the behaviour of cost curves in the Short run and long run and arrives at the conclusion that both the curves are U-Shaped but the LR cost curves are flatter.

$TC = TFC + TVC$

Ex

Q	TFC	TVC	TC
0	60	0	60
1	60	30	90
2	60	40	100
3	60	45	105
4	60	55	115
5	60	75	135



$TVC \uparrow = Q \uparrow$

Upto point T' (point of inflection), the firm is using few variable inputs that law of diminishing marginal returns is not operating and TVC increases at a decreasing rate. Beyond T', TVC starts increasing rate

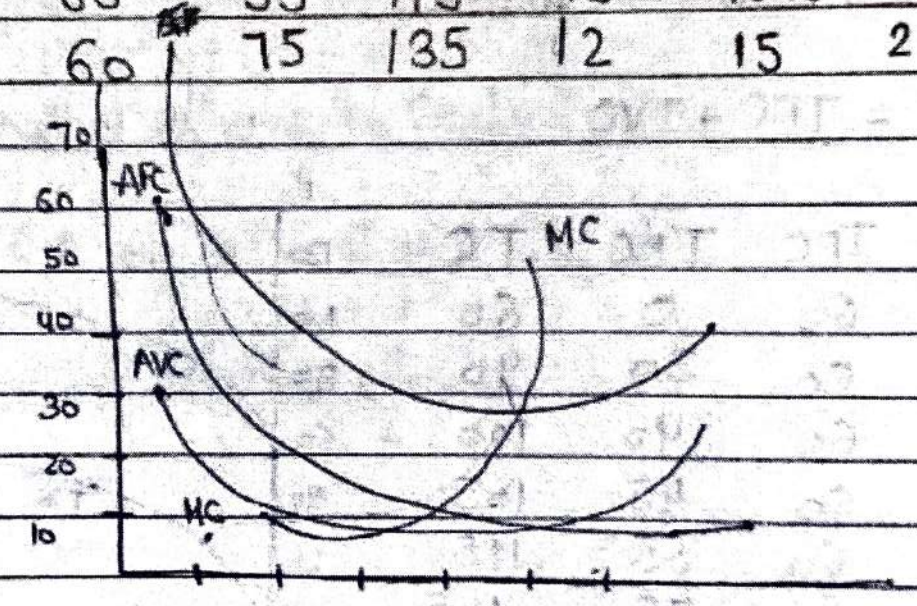
Short run per unit cost curves

$AFC = \frac{TFC}{Q}$; $AVC = \frac{TVC}{Q}$; $AC = \frac{TC}{Q}$

$= AFC + AVC$

$MC = \frac{\Delta TC}{\Delta Q}$

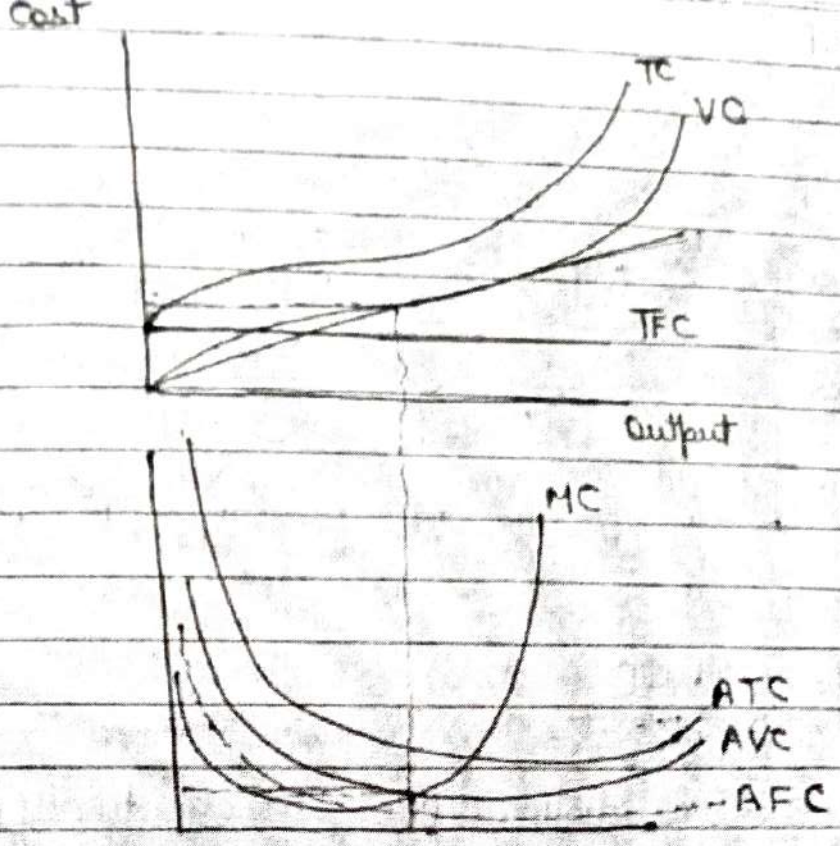
Q	TFC	TVC	TC	AFC	AVC	AC	MC
1	60	30	90	60	30	90	—
2	60	40	100	30	20	50	10
3	60	45	105	20	15	35	5
4	60	55	115	15	13.75	28.75	10
5	60	75	135	12	15	27	20



AVC, AC and MC Curves are U-Shaped.

AC is U-shaped coz:

* Interaction of AFC and AVC
* Law of variable proportions



MC crosses the AVC and AC curves at their minimum points

Long Run Average Cost Curve

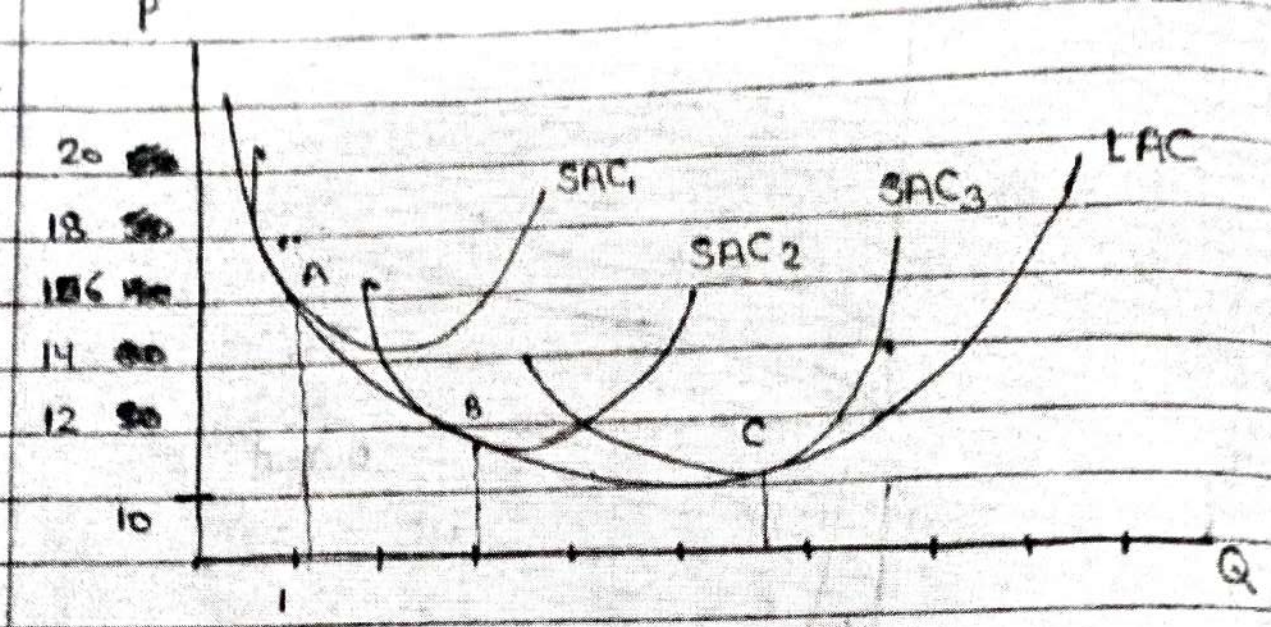
- There are no fixed factors
- LAC curve is the envelope of the SAC curves.

SAC 1	
Q	AC
1	20
2	17
3	15·5
4	15
5	16

SAC 2	
Q	AC
3	16
4	13
5	12·2
6	12
7	13

SAC 3	
Q	AC
5	13
6	11·5
7	10·5
8	10
9	10·5

LAC showcases that when SAC curve from 1st production unit is declining & new plant is setup as lowest point of 1st SAC curve will be lower than SAC of 2nd curve

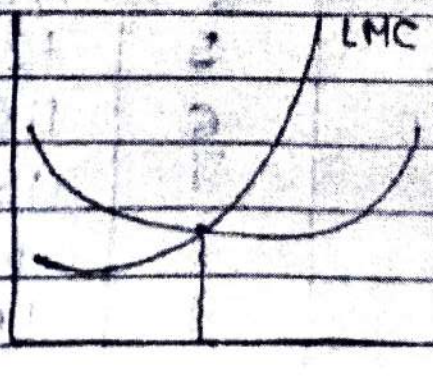


Shape of LRAC

- The SAC curves decline at first, but eventually rises because of the operation of law of diminishing returns.
- In long Run Shape of LAC is determined by economies and diseconomies of scale.

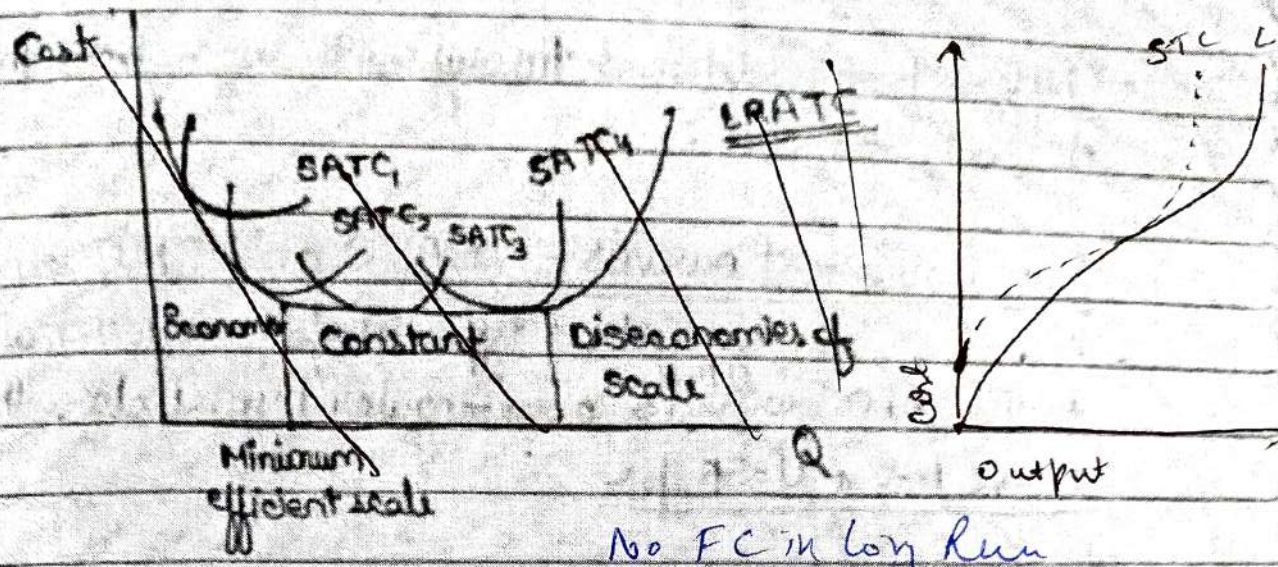
→ As out put expands from very low levels, IRS causes LAC to decline.
But as output becomes greater, Diseconomies of scale cause LAC curve to rise.

Long Run Average and Marginal Cost



- When a firm is producing at an output at which LAC is falling. LMC < LAC. Vice Versa
- Two curves intersect at A, where LAC achieves its minimum

Short run and LR Average TC curves



No FC in Long Run

★ Economies of scale = LRAC falls as the qty of output ↑
Diseconomies " " = LRAC rises as the qty of output

Constant returns to scale = LRAC stays the same as qty of output changes.

→ Arises because higher production levels allow specialization among workers, which permits each worker to become better at a specific task.

→ Arises because of coordination problems that are inherent in any org.

Modern Theory of Cost

- Shape of cost curve is L-shaped instead of U-shape due to reserve capacity
- Reserve capacity is used when production needs to be increased for seasonal fluctuations and greater flexibility for repairs of broken down machinery, also gives freedom if demand increases.

Short Run Cost Curve

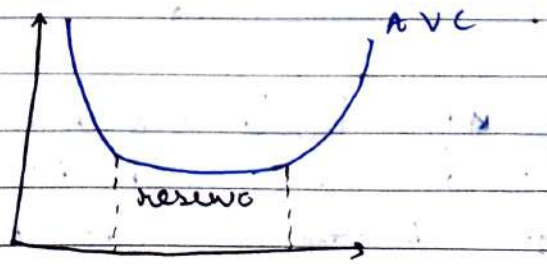
SAVC SAFC SMC SAC

Long Run Cost Curve

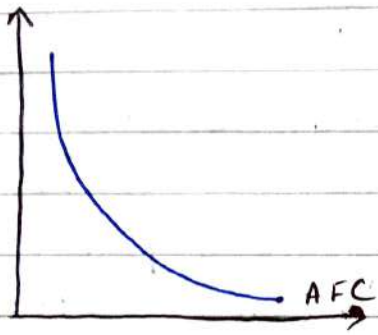
LMC LAC

Short Run Cost Curve

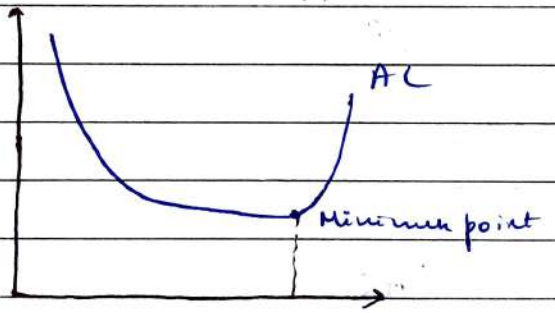
1. AVC (SAVC): It is saucer-shaped. First AVC declines with increase in output it becomes constant till reserve capacity is utilised after starts increasing.



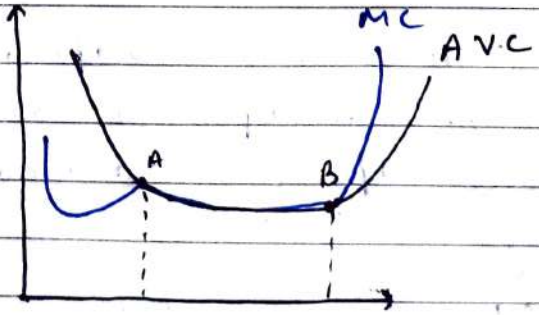
2. AFC (sAFC): It keeps on declining with increase in production. It has a shape of rectangular hyperbola



3. AC (SAC): It is a combination of AFC and AVC. It falls continuously upto a point, after which it becomes constant. Nearby minimum point then starts rising



4. MC (SMC):



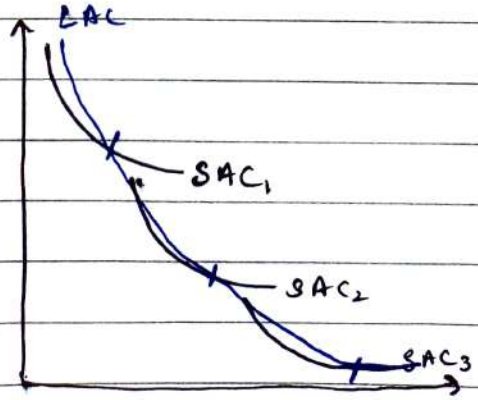
In initial stage MC falls and remains below AVC till A then it becomes equal to AVC from A to B and rise above ~~B etc~~. AVC after B.

Long Run Cost Curve

LAC ⇒ In long run all cost are variable. LAC and LMC are L-shaped. It consists of mainly production cost and Marginal cost. Due to increase in production, production costs are falling continuously due to technical progress and learning by doing. Marginal cost may rise due to enlarged scale of production. As fall in production cost is more than rise in marginal, LAC goes on falling with increased output.

Output	PC	MC	Cost
10	100	100	200
20	80	110	190
30	60	120	180
40	40	130	170
50	20	140	160

It was observed that producers use 2/3 of their production capacity in SR and it joined will give LAC



LMC

Shape of LMC curve corresponds to shape of LAC curve. If LAC is L-shaped and continuously falling LMC will be falling and falling portion will be below falling portion of LAC.

When LAC is inverted J-shape then LMC will also be inverted J-shape and remains below LAC but when LMC becomes constant LMC also becomes constant and coincides with it.