

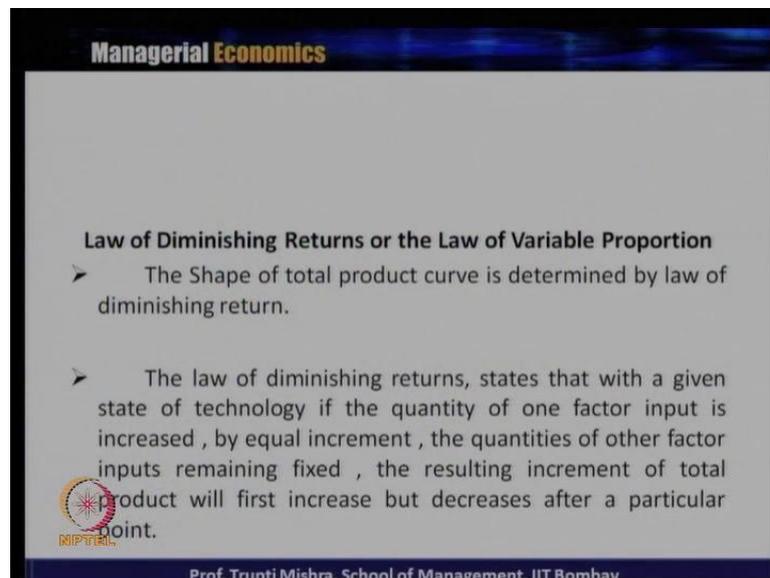
**Managerial Economics**  
**Prof. Trupti Mishra**  
**S.J.M School of Management**  
**Indian Institute of Technology, Bombay**

**Lecture - 34**  
**Theory of Production - II**

As I told you that, even if there is increase in the labour, still at a certain point in the review if you remember in the previous table certain level there is a no change in the output or there is a small change or there is a decrease in the output.

Now, what is the logic behind it? The logic, the relationship between the total product, the marginal product, and the average product, that is explained with a help of law of diminishing return. And that explains the logic also that why there is no change in the output or why the output decreases when you increase more and more of the input, particular input, keeping the other input as the fixed.

(Refer Slide Time: 31:46)



**Managerial Economics**

**Law of Diminishing Returns or the Law of Variable Proportion**

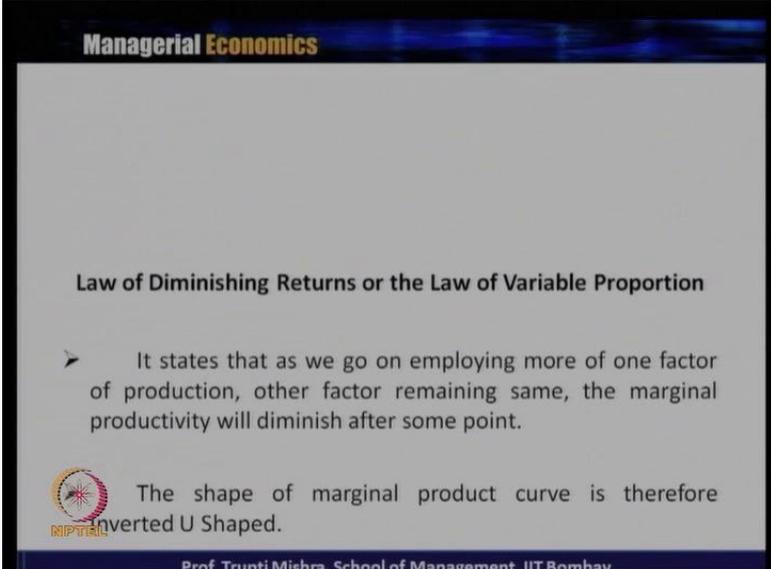
- The Shape of total product curve is determined by law of diminishing return.
- The law of diminishing returns, states that with a given state of technology if the quantity of one factor input is increased, by equal increment, the quantities of other factor inputs remaining fixed, the resulting increment of total product will first increase but decreases after a particular point.

Prof. Trupti Mishra, School of Management, IIT Bombay

So, the law of diminishing return or the law of the variable proportion the logic or theory that is generally known as the, that is generally at the background of the shape of the total product curve. So, now, what is the law of diminishing returns? It state that with a given set of technology, if the quantity of one factor input is increased by equal increment, quantity of the other factor inputs remaining fixed, the resulting increment of total product will first increase but decrease after a particular point. So, in a typical in case of a short run, if capital being

fixed, only there is a change in the labour, initially the total product will increase, but after a particular point, even if there is a increase in the labour still it will decrease.

(Refer Slide Time: 32:37)



**Managerial Economics**

**Law of Diminishing Returns or the Law of Variable Proportion**

- It states that as we go on employing more of one factor of production, other factor remaining same, the marginal productivity will diminish after some point.

The shape of marginal product curve is therefore inverted U Shaped.

Prof. Trupti Mishra, School of Management, IIT Bombay

It stated that, as we go on employing more of one factor of production, other factor remaining same, the marginal productivity will be diminished after some point. So keeping capital as fixed, the, if you are going on increased the labour after a particular point, generally the marginal productivity will diminish, and that is the reason the shape for marginal product curve is inverted U shape.

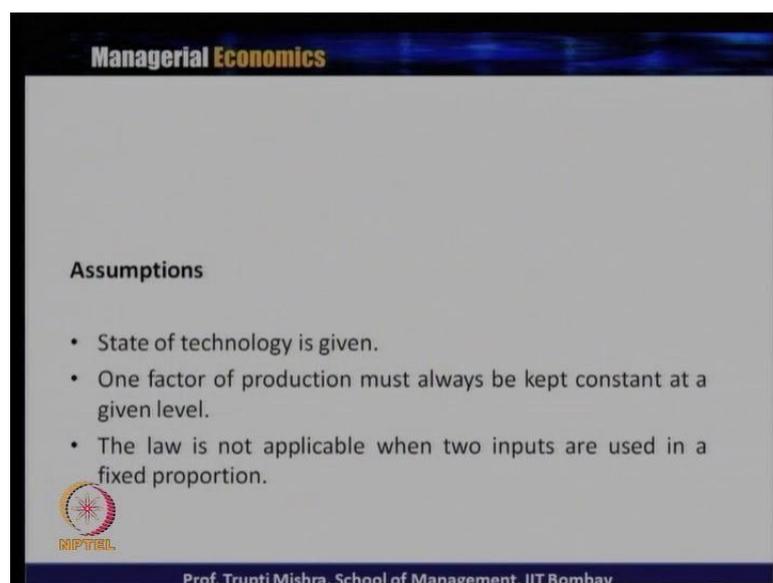
I will just give you a small example of a photo copy machine, right. If there is a copy or if there is a photo copy machine, now what is the working hour can be? Working hour can be 8 hours, 10 hours. Here, what is capital? or What is k? The photo copy the machine is the capital or photo copy of the machine is the, or may be the capital or it may be the k.

Now, to run that to 8 to 10 hours may be two persons are good enough. For one person it is over burden, but for two person it is good enough. But if the shopper is going to employ even more workers, it is not going to increase the total product, rather it is going to decrease. So, the same concept or same logic over here if the total is fixed, the ideal match of labour should be used, even if once you cross that idea of both capital and labour, if you are still going on adding labour to it, the total product is not going to increase, initially may be it will increase but the photo copier machine can be run for 12 hours 15 hours, but that is where capacity of machine we cannot over use it.

And that is the reason it will increase initially of level and after that it will decrease. So, the shape of the marginal product, and once it decreases the total product decreases, it means the marginal product is negative; and that is the reason that is the shape of the marginal product is therefore, inverted U shape.

And when there is a increase in the total product, marginal product increases, because the addition to the total product is positive, and that is the reason the marginal product is increasing, and after reaching a threshold level, where, after that point, whatever there is a increase in the labour still the total product is not going to increase, then in this case the total product decreases, and the marginal product becomes negative. That we will explain through a graph, that how the behaviour of the total product, average product, and the marginal product, changes, when there is a use of more of the one input keeping the other input as the fixed level.

(Refer Slide Time: 35:22)



**Managerial Economics**

**Assumptions**

- State of technology is given.
- One factor of production must always be kept constant at a given level.
- The law is not applicable when two inputs are used in a fixed proportion.

**NPTEL**

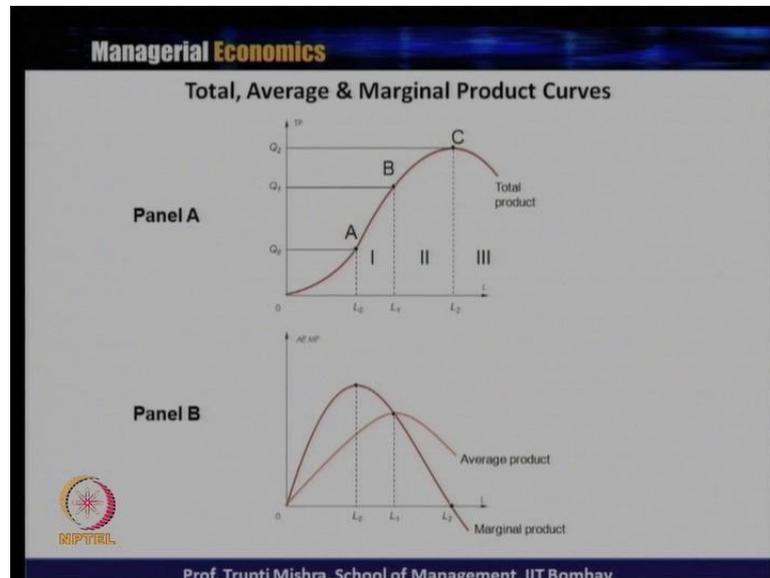
Prof. Trupti Mishra, School of Management, IIT Bombay

There are few assumption being taken, the state of technology is given, one factor of production must always be kept constant at a given level,  $k$  has to be constant; only there has to be change in the labour. The law is not applicable when two inputs are used in a fixed proportion. Any way the third one is not come into picture if you are maintaining the second one that is one factor production must always be kept constant at a given level.

So, the second level should not be used at the same level, and because the law will not be applicable when the two inputs are used in the fixed proportion. Like the typical photo copier machine, if you are buying one more photo copier machine and still you are using two units

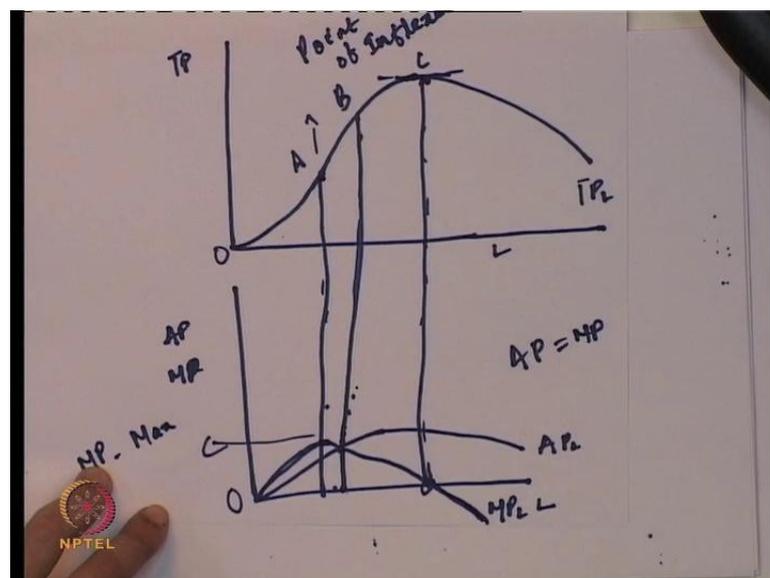
of labour, you are still total product bound to increase. But that you cannot do in the short run, because one input has to be fixed in the short run, otherwise the law will be not valid or the law will not be applicable.

(Refer Slide Time: 36:16)



This is the typical, explanation of the total average and marginal product curve. If you look at, the total product initially increasing, reaching to the maximum and then it is decreasing; average product is increasing and then it is decreasing; and similarly, marginal product is also increasing and decreasing.

(Refer Slide Time: 36:46)



Now we will see the logic of this shape of the total product curve. Here we will take the labour unit, here we will take the total product, here we will take the average product, here we will take the marginal product. Initially the total product increases, at the increasing rate up to this point, then it increases at the decreasing rate up to this point, and from this point onwards it decreases. So, this is the total product of the labour.

We will see corresponding to this, our marginal product is maximum; then corresponding to this one when the total product is maximum, our marginal product is 0; and after this the marginal product becomes negative.

This is our point A, this is our point C. Now, what is the behaviour of the average product? Average product changes in the same way as the total product changes. So, average product will initially increase, and then it will decrease when there is a decrease in the total product. So, we get 3 points, or the 3 turning points of this graph.

This is our total product that is initially it increases at the increasing rate, then it increases at the decreasing rate up to the point C, and then it decreases. Then average product initially increases, then it starts to decrease; marginal product increases and then it decreases.

Now, what is the logic behind this? Why it is increasing or why it is decreasing? Now at the point 0, if you look at this point 0, the labour unit is equal to 0 and the value product will be equal to 0; obviously, the value of marginal product average also be 0. So, all the 3 curves start from origin; that is total product, marginal product and the average product. Total product is initially convex to the origin till the point A and then it becomes concave. As long as total product curve is convex, marginal product is increasing.

When the total product curve is concave, marginal product is decreasing and it is also sometimes in the negative segment. The point A on the total product curve is called as the point of inflexion. Because at this point, the curve is changing its curvature and at corresponding to this, the marginal product will be maximum; average product is maximum at this point B, and at this point also the average product is equal to the marginal product. Corresponding to the maximum point of the total product curve that is the point C, marginal product has to be the 0; to the left of point C, total product is increasing; to the right of point C total product is decreasing, and the marginal product is negative.

(Refer Slide Time: 40:50)

**Managerial Economics**

**Total, Average & Marginal Products**

- Since the MP curve is must be decreasing when the average product is maximum, the MP curve reaches maximum before the AP curve.

NPTEL

Prof. Trupti Mishra, School of Management, IIT Bombay

Now since the marginal product is decreasing, when the average product is maximum then the marginal product curve reaches the maximum, before the average product curve.

(Refer Slide Time: 40:54)

**Managerial Economics**

**Marginal and Average Product**

- When AP is rising, MP is greater than AP
- When AP is falling, MP is less than AP
- When AP reaches it maximum, AP = MP

NPTEL

Prof. Trupti Mishra, School of Management, IIT Bombay

Now, what is the relationship between this marginal and the average product? When average product is increasing, marginal product is greater than average product. So, if you remember

in the first phase when the marginal product is increasing, till the time the total product is convex, if the original product is increasing then the average product is also increasing, and it is less than the marginal product. When average product is decreasing marginal product is less than average product; when average product it reaches its maximum then average product is equal to the marginal product.

(Refer Slide Time: 41:34)

**Managerial Economics**

**The Three Stages of Production**

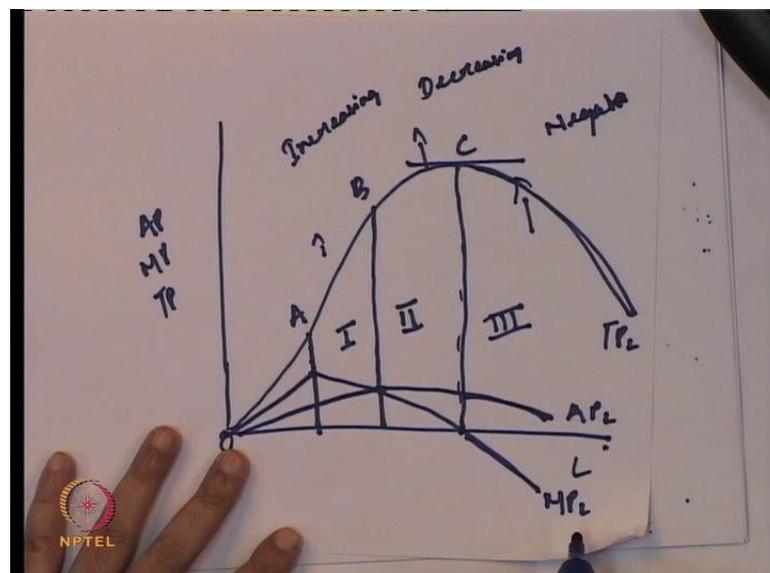
**Stage I: Stage of Increasing Returns:**

- AP is increasing and the MP is greater than the AP. Up to point B on the TP curve Stage I exist.
- AP is increasing, but MP is increasing first up to point A then decreasing.

Prof. Trupti Mishra, School of Management, IIT Bombay

In this case, we have identified the three stages of production. Now, what are the three stages of production? On the basis of this relationship between the average product, total product, and marginal product, there are three stages of production.

(Refer Slide Time: 41:51)



Now we will see, what are these three stages of production? This is the total product of labour, this is the marginal product of labour, and this is the average product of labour. So, point 1 is A, point 2 is B, and point 3 is C. At this point A, marginal product is maximum; at this point B, there is a equality between average product and marginal product, and average product is maximum; corresponding to point C total product is maximum and marginal product is 0. In the X axis we take labour, Y axis we take average product, marginal product and total product.

Corresponding to this, we have identified the three stages of production. From origin to point B we have stage 1, between point B to C we have stage 2, and beyond point C we have stage 3. Stage 1 is known as increasing return because in this case, average product is increasing, marginal product is increasing partly, and when it is decreasing also it has not reached 0, and total product is increasing. That is the reason, stage 1 is known as the stage of increasing return.

Let us see, what happens in case of stage 2. Stage 2, total product is increasing, average product has started decreasing, marginal product is decreasing, but marginal product is reaching 0, till now it has not reached the negative segment. So, stage 2 is known as the decreasing return because both average product and marginal product is decreasing, and also the total product is increasing at the decreasing rate.

Let us see what happens in case of stage three. Stage three is known as the stage of negative returns. Because total product is decreasing, marginal product is negative, and average product is also decreasing. So, stage one is increasing return, stage two is decreasing return, and stage three is negative return. From origin to point B is stage one, between point B to point C decreasing, and beyond point C this is the stage of negative return.

We have three stages of production process. In case of stage one, it is known as increasing because total product, average product is increasing, marginal product is partly increasing upto point A and then it is decreasing. Stage two is known as decreasing return because average product, marginal product and average product is decreasing, and total product is increasing at the decreasing rate. Stage three is known as the negative return because marginal product is negative, total product and average product is decreasing.

(Refer Slide Time: 45:42)

**Managerial Economics**

**The Three Stages of Production**

In which stage would the rational producer like to operate?

 MPTEL

Prof. Trupti Mishra, School of Management, IIT Bombay

Now the question comes, if it is a case of rational producer where the optimization problem is to maximize the output the minimum of cost, in which stage the rational producer would like to operate; whether in stage one, whether is stage two, or whether in stage three.

(Refer Slide Time: 45:55)

**Managerial Economics**

**The Three Stages of Production**

In Stage I, MP and AP both are rising, and the MP is more than AP.

- A given increase in variable factor leads to a more than proportionate increase in the output.

The producer is not making the best possible use of the fixed factor. A particular portion of fixed factor remains unutilized.

 MPTEL

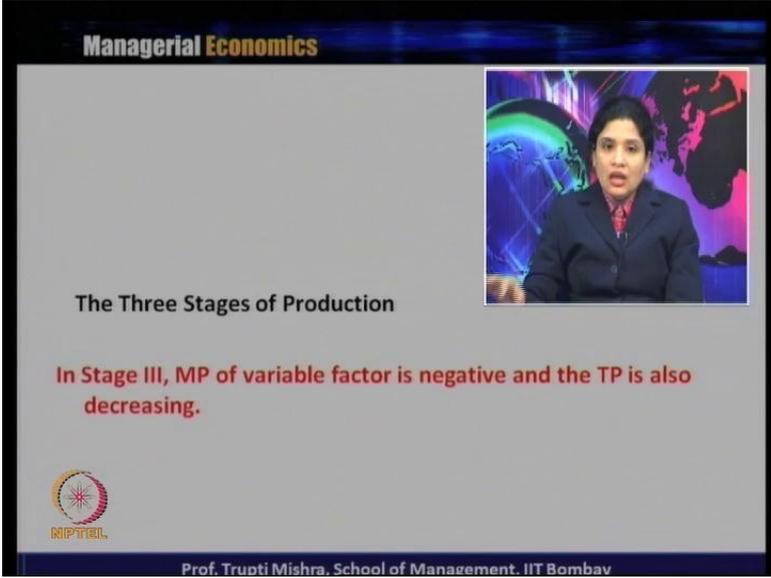
Prof. Trupti Mishra, School of Management, IIT Bombay

Now let us see what happens in three stages of production. In stage one, marginal product and average product both are increasing, but marginal product is more than average product. And what is the implication of this? A given increase in the variable factor lead to more than proportionate increase in the output. So, whenever there is a change in the labour input, the marginal product is more because the additional unit of labour is contributing more to the production.

So, the producer is not making the best possible use of fixed factor, a particular portion of fixed factor remain unutilized. Like if you are taking a example of a photo copier machine and if you are using for one machine only, only one labour the maximum capacity the worker can work or worker can run the machine is for 8 hours not more than that.

So, in this case, there is a underutilization of the machine, and the same logic is here, that in that case of first stage, the producer is not making the best possible use of the fixed factor, a particular portion of the fixed factor remain unutilized.

(Refer Slide Time: 47:01)



**Managerial Economics**

**The Three Stages of Production**

**In Stage III, MP of variable factor is negative and the TP is also decreasing.**

**Prof. Trupti Mishra, School of Management, IIT Bombay**

In the second stage, the marginal product of variable factor is negative, and total product is also decreasing. It means, it is the over use of the, both the inputs like whether it is machine, whether it is a worker, whether it is labour, whether capital, there is over use of labour, there is over use of capital, and that is the reason the total product is decreasing and marginal product is negative.

So, stage one, if the producer is operating there under utilizing one of the resources which is not in the line of the optimization problem where they have to maximize the output using all possible options of using the inputs. Stage three, they are over utilizing it that is the reason it is not possible to operate in stage three, because the total product whatever they are getting that is negative, that is decreasing and the marginal product is negative. So, when they are using more unit of labour, they are not contributing to the total product.

(Refer Slide Time: 48:13)

**Managerial Economics**

**The Three Stages of Production**

**In Stage II, MP and AP both are falling and MP through positive, is less than AP.**

- There is less than proportionate change in output due to change in labor force .
- Hence at this stage the producer will employ the variable factor in such a manner that the utilization of fixed factor is most efficient.

MIPITEL

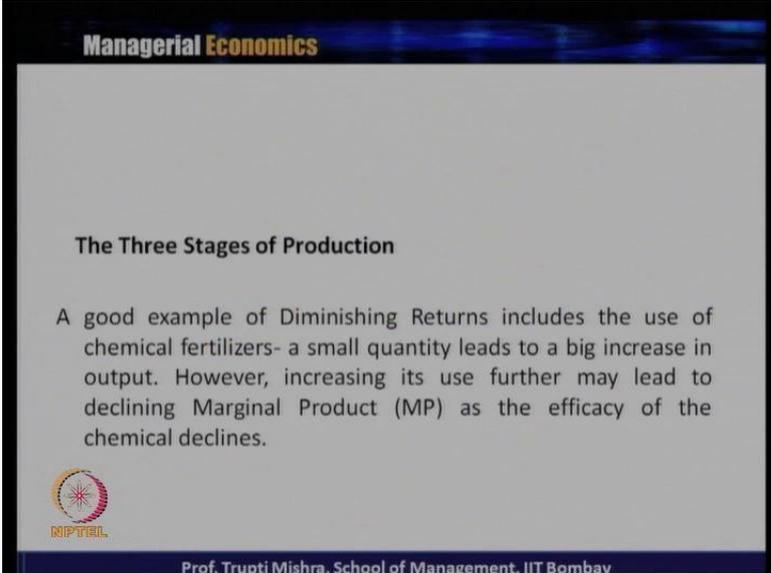
Prof. Truoti Mishra, School of Management, IIT Bombay

Let us see, what happens or what is the logic for stage two? In stage two, marginal product, average product both are decreasing; and marginal product is positive and less than average product. What are the implications of this? There is a less than proportionate change in output, due to change in the labour force. Hence at this stage, the producer will employ the variable factor in such a manner, that the utilization of fixed factor is more efficient. So, in this case, the additional contribution of what the labourer is giving, that is less than the average product. So, at this stage the producer will employ the variable factor in such a manner, that the utilization of fixed factor is most efficient.

So, it is not underutilization of the fixed factor, not the over utilization of both the fixed factor and the variable factor, So, stage two is basically considered as the ideal stage for all rational producer to operate, because at this stage the producer will employ the variable factor in such a manner, that the utilization of the fixed factor is most efficient; or the simply we can put the logic is like this, that there is a efficient utilization of both the inputs or both the factor

of production, that is variable factor, and the fixed factor; and that is the reason the rational producer should operate in case of the second stage, in order to optimize their maximization of output with all possible options.

(Refer Slide Time: 49:40)



**Managerial Economics**

**The Three Stages of Production**

A good example of Diminishing Returns includes the use of chemical fertilizers- a small quantity leads to a big increase in output. However, increasing its use further may lead to declining Marginal Product (MP) as the efficacy of the chemical declines.

 IITBOMBAY

Prof. Trupti Mishra, School of Management, IIT Bombay

Now, what are the examples, when you take into the real life, whether there is really a evidence of this law of diminishing return. And we have taken a case of the chemical fertilizer when it is getting used, as one of the input in the, to increase the output. So, here the good example of diminishing return includes the use of chemical fertilizers, and a small quantity leads to big increase in the output. But there is always a limit, increasing its use further may lead to decline the marginal product as the efficacy of the chemical decline.

You know that for 1 acre of land, or for may be 10 units of output, what is the chemical required, fertilizer required, chemical fertilizer required. Till the time it is given in that amount, it always contribute to increase the output, but the overuse of that is it is not going to increase the output. So, you cannot just going on increase the input the chemical fertilizer in order to increase the output, and if you are continuing to doing so maybe there will be decrease in the output because there is a over use of one of the inputs.

(Refer Slide Time: 50:51)

**Managerial Economics**

Law of Diminishing Return -Example

Number of Workers	Unit of product produced	Marginal Product
1	10	10
2	25	15
3	45	20
4	60	15
5	70	10
6	60	-10

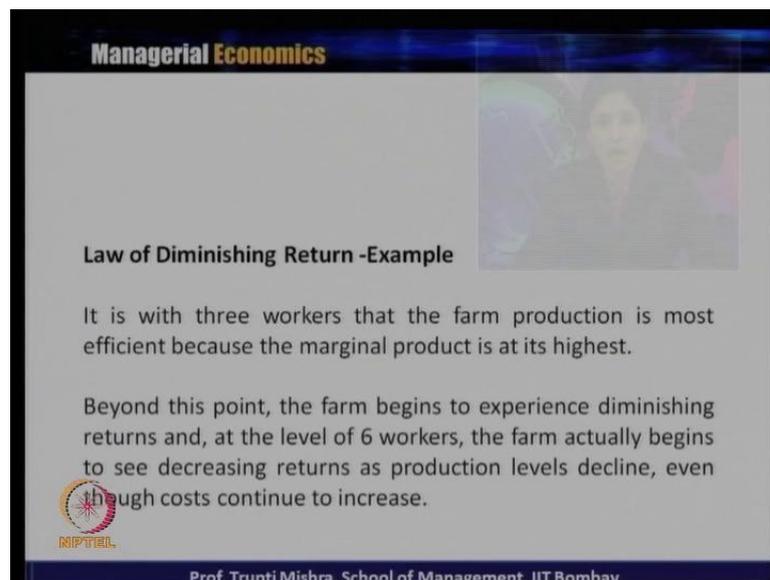
MPTEL

Prof. Trupti Mishra, School of Management, IIT Bombay

Similarly, we can take the example of, the number of worker or units of product produce. So, the first column in this case gives us the number of workers, that is from 1 to 6 and unit of product produced is from 10 to 60, and here we can see how the marginal product behaves actually, or how the marginal product takes place.

In the first case, the number of worker is 1, unit of product produced is 10, the marginal product is 10, because this is the total contribution. Number of worker is 2, unit of product produce is 25, the marginal product is 15; 3 workers hired they are producing 45 units, the marginal product is for the 3rd unit the additional contribution to the total product is 20, for the 4th unit it is 15, 5th unit is 10 and 6th unit is go in a negative direction because after 5th unit, even if they are hiring a additional unit of labourer, he is not contributing, he is decreasing the total output. So, number of workers increasing, so it is the total product is increasing up to a level and then there is a decrease in the additional contribution.

(Refer Slide Time: 52:05)



**Managerial Economics**

**Law of Diminishing Return -Example**

It is with three workers that the farm production is most efficient because the marginal product is at its highest.

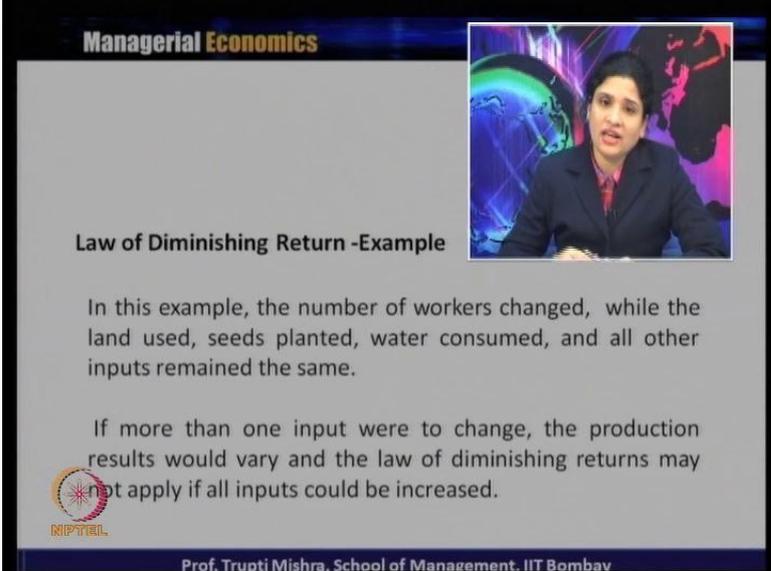
Beyond this point, the farm begins to experience diminishing returns and, at the level of 6 workers, the farm actually begins to see decreasing returns as production levels decline, even though costs continue to increase.

MIPTEL

Prof. Truoti Mishra, School of Management, IIT Bombay

How we can interpret this? It is with three workers that the firm production is most efficient because marginal product is at its highest. Beyond this, if the worker is getting used, if there are more number of workers being hired, then the marginal product is declining, and total product is increasing at a decreasing rate. Beyond this point, beyond the hiring of three workers, the firm begins to experience a diminishing return, and at the level of 6 workers, if you remember the previous table, the information of the previous table, the firm actually begins to see the decreasing return as production levels decline, because when they are hiring 5 units of L laborers and that leads to 70 units of output; and when there are 6 unit of laborers being hired, the production laborers declines from 70 units to 60 units and that also leads to costs continue to increase.

(Refer Slide Time: 53:01)



**Managerial Economics**

**Law of Diminishing Return -Example**

In this example, the number of workers changed, while the land used, seeds planted, water consumed, and all other inputs remained the same.

If more than one input were to change, the production results would vary and the law of diminishing returns may not apply if all inputs could be increased.

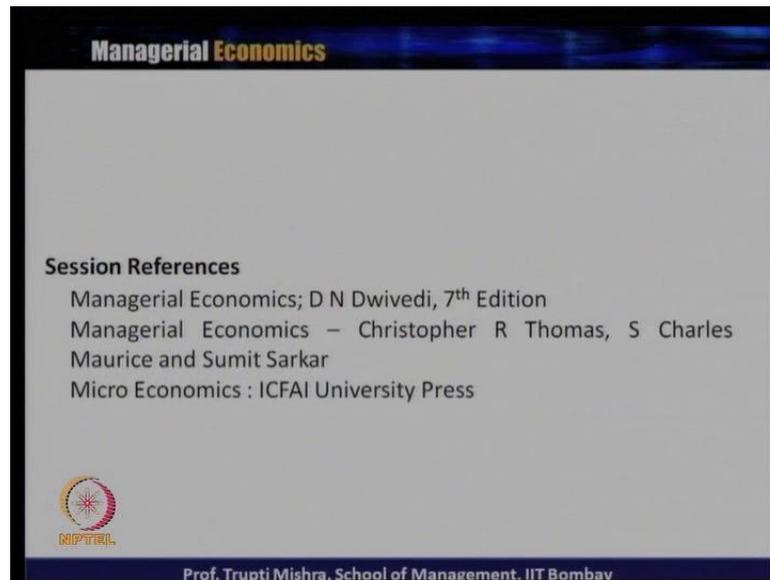
MPTEL

Prof. Truoti Mishra, School of Management, IIT Bombay

So, that is the evidence of the decreasing return, and, but you can again twist to this example that, it is not only changing the input, in this example only the number of workers changes, when there are land use, seeds planted, water consume and all other inputs remain same. But if more than one input is changed, the production level will not decrease rather it will increase.

But that is beyond the scope of a short run production function. In case of short run, we can only increase one input keeping all other input constant. But if it is not a case of short run, if more than one input were to change the production result would vary and the law of diminishing return may not apply, if all inputs could be increased. And that is the reason if you look at, one of the assumption we took in before discussing the law of diminishing return that there is only one factor input as to variable or the other factor input has to be constant. And that is the reason, you can get the evidence of law of diminishing return, if you are keeping strictly within the frame work that you can only increase one factor input all other input remain constant.

(Refer Slide Time: 54:11)



**Managerial Economics**

**Session References**

- Managerial Economics; D N Dwivedi, 7<sup>th</sup> Edition
- Managerial Economics – Christopher R Thomas, S Charles Maurice and Sumit Sarkar
- Micro Economics : ICFAI University Press

 MPPTEL

Prof. Trupti Mishra, School of Management, IIT Bombay

So, with this we will complete this short run production function. These are the session references, the books that is being followed to preparation for this session. And in the next class we will continue the long run production function, the long run analysis. And then we will see the different kind of production function like the Coob Doughlas' and C E S production function.