

Petroleum Economics and Management
Prof. Anwsha Aditya
Department of Humanities and Social Sciences
Indian Institute of Technology, Kharagpur

Module - 07
Petroleum Discoveries and Structural Changes
Lecture - 31
Production Possibility Frontier

Hi everyone, welcome to our NPTEL course Petroleum Economics and Management. And I am your instructor Dr. Anwsha Aditya. So, we are in module 7 where we are discussing a Petroleum Discoveries and Structural Changes. We will be starting a theoretical model and for that we are now devoting some time to understand some basic concepts of economics.

So, one such very important concept that we need for our theoretical model is the production possibility frontier. So, this is our 31st lecture in our course where we are going to discuss Production Possibility Frontier.

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Concepts Covered


- ❖ Concept of PPF: Definition, Graphical representation
- ❖ Slope of the PPF
- ❖ Shape of PPF and the Laws of Production

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So, in today's class we are going to discuss what do we mean by a production possibility frontier. So, we will define the production possibility frontier, we will draw the production possibility frontier and we discuss the slope and shape of the production possibility frontier.

Because this is important because the theoretical model that we are going to study in this module is based on how the production possibility frontier changes once resource is discovered. So, we need to know from where this production possibility frontier is coming what is that how the slope is determined and then we will discuss the particular shape of the production possibility frontier?

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Production Possibility Frontier (PPF)

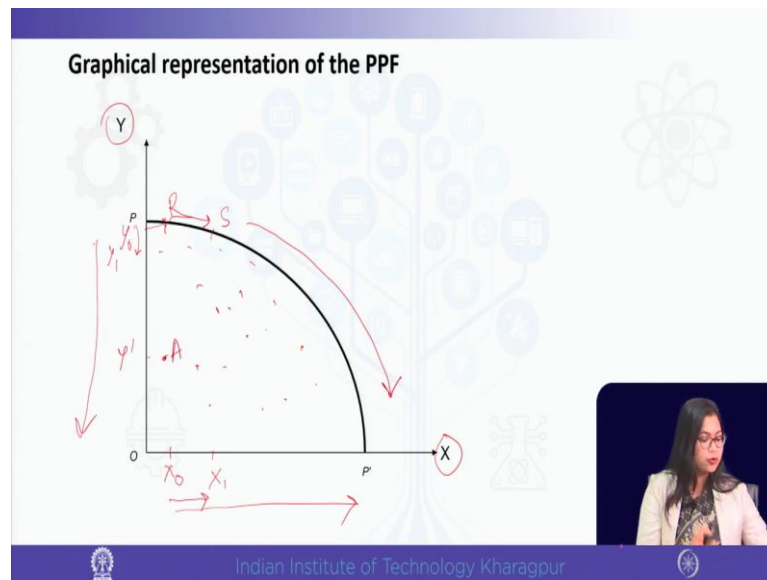
❖ *Production Possibility Frontier (PPF)* or *Production Possibility Curve (PPC)* is the locus of technologically maximum (and efficient) output level of one commodity that a country can produce for different levels of production of the other commodity by exhausting all the resources of the economy.

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So, what do we mean by a Production Possibility Frontier (PPF) or Production Possibility Curve (PPC)? So, this is defined as the locus of technologically maximum and efficient output level of one good that an economy can produce for different levels of production of the other good by using all the resources of the economy, may not be clear. So, I will just explain with a graph.

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Suppose we consider a 2 good economy you see often we work with a 2 good model because we can present represent it graphically you can see visually and if we see things visually that helps us to understand we can retain it with us. So, and that makes sense also because often we can consider one of the good as a very important good, suppose your laptop and the all other goods can be considered as a consolidated or set of all other goods.

Suppose you have an n good world you consider good 1 say your laptop which is so important for you and all other goods good 2 to good n you can consider good Y ok. So, often this 2 good world make sense. So, we are representing a 2 good economy where we are plotting good X on the horizontal axis and good Y on the vertical axis, ok.

So, you see how what is the production possibility frontier. So, this is the locus of technologically maximum and efficient output level of one good that the country can produce for different levels of production of the other good with given resources and exhausting all the resources of the economy. That means, you see what happens say for a given amount of input means say sorry output of one good say X.

Suppose the country was initially producing output X_0 . So, how much of the other good Y the country can produce, if it is using all its resources ok? Say the answer is if the country was initially producing X_0 amount of good X by using all the resources suppose the country can produce Y_0 amount of good Y.

Now, suppose the country is now producing X_1 amount of good X and you can see that the country can produce, now Y_1 amount of good Y. So, in these Y you see you get different combinations of the 2 goods that the economy can produce using all the resources. Means, when I am saying that the economy is producing Y_0 that is the maximum level of production.

The economy can also produce say with X_0 amount of good X the country can also produce say Y dash amount of good Y, but that is not the maximum level of production any point here will be feasible ok. So, this is the production possibility set with given resources and given technology any points inside the production possibility set is feasible. But what happens on the boundary?

Boundary gives you the upper limit or maximum possible amount of one good that the country can produce with given amount of production of the other good by using all resources. Because you see if you consider if you take this point say point A the combination X_0Y dash. What is happening? The economy is not using all the factors of production there will be unemployment right.

So, if the economy is exhausting all the factors of production so with X_0 amount of good X the country at max can produce Y_0 amount of good Y and in similar fashion we can get many other points and if we join all such points the curve we get is called the Production Possibility Frontier or the Production Possibility Curve PPF or PPC ok.

So, this is the locus of technologically maximum you see. So, this PPF is basically with a given technology this is the upper limit as we already discussed in the case of production, if there is a technological improvement then with given amount of resource now more and more production points become feasible you can now go beyond the PPF. So, the PPF will expand the production set expands ok, but with a given technology then this is not possible these points are not possible ok.

And see exhausting all the resources and that means, along the PPF the full employment is also maintained. So, output level of one good with given output level or different levels of production of the other good by using all the resources. So, I hope the concept is clear ok.

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Assumptions

- ❖ The concave PPF drawn here is based on the following assumptions:
 - No externality;
 - Perfect competition;
 - Diminishing MP with non-IRS (either CRS or DRS).
(weak IRS)

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Slope of the PPF

- ❖ PPF is negatively sloped as there is trade-off between output of the 2 goods.
- ❖ With given endowment and technology, if we want to produce more of one commodity, we have to sacrifice the opportunity to consume the other commodity.

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Now, you see we have drawn a concave PPF. So, you can ask why this concave PPF? So, I will come to the concavity of the PPF, but before that let us first interpret the slope of the PPF as you can see that it is negatively slope. So, why the PPF is negatively slope? It is simple because you see you have given amount of resources and along the PPF just now I mentioned that full employment is already maintained right and technology is also given at a particular point of time.

So, suppose now you are producing initially at say point R, where you are producing X_0 amount of good X and Y_0 amount of good Y. Now, if you have to produce one more unit of good X. So, how can you do so? You can do. So, only by reducing the amount of good Y production from Y_0 to Y_1 is not it, because you are already you have exhausted all your resources at point R all the resources were fully employed right.

So, how do you go from point R to suppose say point S. So, you can go; you can go from point R to point S by reducing the output of the other good Y. So, that is why there is a trade-off between the two goods. So, with given amount of endowment of factors of production and given state of technology, if we have to produce more of one good, we have to sacrifice the opportunity to consume the other good.

So, this is this sacrificing the opportunity to consume it is also called the opportunity cost. Now, opportunity cost is a very interesting concept in economics. So, it is the foregone cost associated with the opportunities that we are sacrificing. Say when you are listening to this particular lecture you are sacrificing the opportunity to watch a movie right. So, this is the opportunity cost of listening to this particular lecture right.

So, when the country is producing one more unit of a good the country has to sacrifice the opportunity to produce more unit of good Y. If you want to if you are going down along the PPF you are increasing the amount of production of good X you have to reduce the opportunity to produce good Y.

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Interpretation of the Slope of the PPF

- ❖ The absolute slope of the PPF is the *Opportunity cost* or the *marginal rate of transformation in production (MRT)* defined as the units of good Y that the economy must forego to produce an additional unit of good X.
- ❖ This is in fact the ratio of social marginal cost of good X to that of good Y.
- ❖ Assume no externality (activity of one agent affect the utility/cost of another agent).
- ❖ Hence social marginal cost is equal to private marginal cost.
- ❖ Under perfect competition we have marginal cost pricing.
- ❖ Hence, MRT is nothing but the relative *supply price*.



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Hence, the PPF is negatively sloped and you see the slope of the PPF can be interpreted as the opportunity cost. So, the absolute value of the slope of the PPF is the opportunity cost, because you cannot produce more of both the goods at the same time because you are already employed your resources fully or this the slope of the PPF is also called the Marginal Rate of Transformation in production or MRT.

Why? Because you see as we are going down along the PPF you are transforming let us say one good into another is not it. It is as if you are transforming because you are taking resources out from the Y sector and those same resources are utilized in the other sector. So, this is the rate at which the economy is basically transforming one good into another.

So, the MRT or the slope of the PPF can be defined as the units of good Y that the economy has to forgo to produce an additional unit of good X or this is the ratio of social marginal cost of good X to good Y ok. Why? Because see now one thing is you should means make it a point to understand the previous lecture in when we discussed the laws of production concept of production function and isoquant, those were relevant for a particular firm ok; because the firm is deciding how much to produce.

Now, this concept of PPF this is not relevant to the firm this is for the economy as a whole, because you see we are plotting the 2 goods that the economy is producing and you are talking about full employment. So, any point inside this PPF is the production set that means, the set of feasible output levels of the 2 goods that the country can produce, but inside the production set below the PPF there is unemployment.

So, the economy will operate on the PPF where there is full employment. So that means, the concept of PPF is relevant for the entire economy. So, when you are going down along the PPF you are sacrificing the opportunity to produce Y because you are now devoting more resources in the X sector, ok.

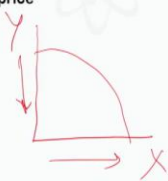

So, when you are producing more of X you have associated marginal cost. What is marginal cost? If you change your output by 1 unit how your cost will change. Now, see this is the social marginal cost because the concept of PPF is relevant to the entire economy not to a particular firm. So, this we should remember, but the other concept of production function and isoquant those were relevant to a firm.

So, with this now we can say we can before discussing the shape of the PPF we make this following assumptions. Say there is no externality I will explain the implication of each of the assumption. Second assumption is perfect competition and third assumption is the law of diminishing marginal productivity and either CRS or DRS ok. Even we can have a weak IRS also I will explain that later as we come to that part.

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Mathematically:

❖ $MRT = \frac{SMC_x}{SMC_y} = \frac{MC_x}{MC_y}$ (no externality) = $\frac{P_x}{P_y}$ = Relative supply price

$$MRT = \frac{SMC_x}{SMC_y} = \frac{PMC_x}{PMC_y} = \frac{P_x}{P_y}$$



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So, what we are saying that the slope of the PPF is basically the MRT the absolute value of the slope of the PPF is MRT. So, you are going down along the PPF means you are sacrificing one good for the other. So, you have the corresponding marginal cost. So, MRT is basically if I write I think it will be helpful for us to understand it is the ratio of the marginal cost of good x to marginal cost of good y.

Now, you see now the implication of the assumptions will come into play. We assume that there is no externality. What do you mean by externality? Externality means when action of one economic agent affects the utility or cost of another economic agent. I think in case of tax also I discussed briefly about externality like pollution creates negative externality.

But there are cases of positive externality is also if you are supposing your neighbour nurtures a garden. So, that is a positive externality for you right. If a road is constructed or a flyover is constructed near your house, so that is a positive externality for you. So,

externality means when action of one economic agent affects the utility or cost of another economic agent.

Now, here we assume that there is no externality. So, in the absence of externality the social marginal cost is equal to private marginal cost, so that is the implication. So, if there is no externality social marginal cost is equal to private marginal cost. Because with externality there arises a divergence between social marginal cost and private marginal cost, like in case of pollution.

If the manufacturing unit pollutes the environment then it is polluting the environment and the government has to incur a cost. So, it creates a negative externality ok. So, the social marginal cost will be greater than the private marginal cost, but now we are assuming no externality.

So, SMC_x are equal to PMC_x ok, so this is the implication. Next implication of the assumption is perfect competition is at the next assumption. What is the implication? We have already discussed many times that in perfect competition price is equal to marginal cost. So, we have marginal cost pricing, because in perfect competition the firms are price taker. So, we are assuming a perfectly competitive market structure over here.

So, PMC_x are basically equal to the prices. So, PMC_x is equal to P_x and PMC_y is equal to P_y . So, MRT is equal to the ratio of SMCs and without externality the ratio of SMC is equal to the ratio of PMC and under perfect competition these PMCs are equal to the price. So, we have marginal cost pricing. So, PMC_x is equal to P_x and PMC_y is equal to P_y . So, this is the relative supply price is not it P_x by P_y price of good x divided by price of good y.

So, this is the derivation of or this is the interpretation of the slope of the PPF which is nothing but the relative supply price ok and why it is negatively sloped we have already discussed.

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Shape of PPF & Laws of production

- ❖ If we move down along the PPF, more of X and less of Y are produced.
- ❖ The shape of PPF is governed by the two laws of production.

a) **Technique effect**: MRT increases by the law of diminishing marginal productivity.

b) **Scale effect**: MRT increases if production technologies in both sectors are DRS, remains constant if CRS and declines if IRS.

The slide features a graph of a concave Production Possibility Frontier (PPF) with axes labeled X and Y. A red arrow points downwards along the curve, and another red arrow points to the right along the X-axis. The slide also includes a small video inset of a woman speaking and the IIT Kharagpur logo at the bottom.

Now, why it is concave? Now, it can be convex also or even it can be straight line also under certain particular assumption we can have a concave PPF. So, the theoretical model that we are going to study will have a concave PPF. So, I will explain the concavity of the PPF. So, we are moving down along the PPF right. It is negatively sloped like we have discussed we are producing more of x and we are reducing the production of y.

So, that means, suppose starting from a particular point in the PPF if we are going down along the PPF we are changing the output composition and along with that resources are also reallocated. So, if you are changing the output, we know that we have the two laws of production which will come into play ok. So, we have the two laws the law of return to scale and the law of variable proportions we will discuss.

So, corresponding to the short run we know we have the law of variable proportion which here triggers a technique effect and in the long run we have the law of return to scale which here triggers a scale effect I will elaborate on the effects.

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Technique Effect & Shape of PPF

- ❖ By diminishing marginal productivity, MC of the expanding X sector increases and that of the contracting Y sector falls.
- ❖ Hence, MRT increases by diminishing **Marginal Productivity**.

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So, what happens we know in the we start with the short run. So, as we are going down along the PPF in the short run what happens? In the short run we can know that if we are producing more of good X, what will happen? We have to employ more and more of labour right. Now, you have diminishing marginal productivity see we have already plotted the marginal productivity curve which is inverted U shape.

So, what happens if we employ more and more labour in the short run to produce more of good X. So, we will have the law of diminishing return to scale operating. What will happen then with diminishing marginal productivity of labour marginal cost will increase in the expanding X sector. So, as you are going down along the PPF your X sector expands and Y sector contracts right.

So, when you are employing more and more of the variable factor in the expanding X sector there will be law of diminishing marginal productivity which will increase the marginal cost of good X. Whereas, in the contracting Y sector that will release labour because from where this labour will come labour will come from? The Y sector because you are already at the starting point you had full employment of labour.

So, labour is reallocated from Y to X. So, Y sector will contract therefore, what will happen in the contracting Y sector marginal cost will fall ok. Now, MRT is already we have shown that it is a ratio of MC_x by MC_y . So, MC_x will increase and MC_y will fall. So, what will happen? MRT will increase right.

So, that means, by the law of variable proportion in the short run which triggers a technique effect MRT is increasing ok. So, by diminishing marginal productivity our MRT is increasing. Now, what about the other effect? Because now over time what will happen now the firm will no longer be constrained with fixed factor.

So, as the firm is moving down along the PPF the firm can now change the capital labour ratio means, the firm can change capital and labour in the same percentage right. So, the firm can change the scalar production.

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Scale Effect & Laws of production

❖ **Scale effect:** MRT increases if production technologies in both sectors are DRS, remains constant if CRS and declines if IRS.

I. DRS: MRT increases.
Under DRS, MC of the expanding X sector increases and that of the contracting Y sector falls.

II. CRS: MRT remains unchanged.
Under CRS, MCs of the expanding X sector *constant* increases and that of the contracting Y sector falls. *constant*.

III. IRS: MRT decreases.
Under IRS, MC of the expanding X sector falls and that of the contracting Y sector increases.

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Now, when the scalar production changes we already know that there operates the return to scale there are three types of return to scale CRS, DRS and IRS. Let us see what happens with CRS ok. With constant return to scale technology as I have already mentioned in the theory of production lecture. So, if inputs are changed in the same proportion output will also change by the same proportion. If labour and capital both are doubled output will also be doubled.

So, what will happen? Under CRS marginal cost of both the sectors will remain unchanged ok. I think this will be marginal cost of the expanding X sector remains constant here it is wrong marginal cost of the expanding X sector remains constant and contracting Y sector also remains constant both of these should be constant I will correct it in the final PPT sorry for this.

So, both are constant. So, if the marginal cost remains constant because under CRS the resources can be reallocated without incurring any additional cost because now if the firm is expanding the scale of production output will change in the same proportion. So, marginal cost remains unchanged. So, MRT remains unchanged under CRS ok. So, marginal cost of the expanding X sector and contracting Y sector in both the sectors they remain constant and MRT also remains constant ok.

Now, what happens under decreasing return to scale? If under decreasing return to scale as we have already mentioned if labour and capital are doubled output is less than doubled. So, what will happen? The marginal cost of the expanding X sector will increase. Why? Under decreasing return to scale, we have increasing cost. Why? Because if we now have to double our output, we have to more than double our input right because doubling the input less than doubles the output.

So, to double output we have to more than double input therefore, marginal cost will increase in the expanding X sector and marginal cost will fall in the contracting X Y sector. That means, once again you see MRT will increase under DRS. Now, what is the third type of return to scale? That is increasing return to scale, where if we double both the inputs output gets more than double right. So, what will happen to the marginal cost of the expanding sector?


Now, if you want to double your input that you sorry if you want to double your output you can do, so by less than doubling of input. So, that means, in the expanding X sector marginal cost falls and in the contracting Y sector marginal cost increases. Therefore, what will happen now? Now, MRT decreases. So, you see the in the long run the return to scale has a scale effect on the slope of the PPF and we have three types three impacts. So, we cannot say definitely what will happen.

So, depending on the return to scale that the particular underlying production function exhibits we can have the MRT to be increasing decreasing or even constant. Now, you see we have discussed these two impacts separately, but of course they will be operating together in the long run.

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Combining the two effects:

- ❖ Hence, for CRS and DRS technologies, along with diminishing marginal productivities, the MRT increases. The PPF, thus, would be strictly concave.
- ❖ **CRS & DRS:** MRT is rising, hence PPF is concave.
- ❖ For IRS, the scale and technique effects move in opposite directions. For weak IRS, the technique effects dominate so that the PPF is concave. But for a strong IRS, the scale effect dominates so that now the PPF is convex.
- ❖ **IRS:** MRT can be rising (if $SE < TE$ for weak IRS) → PPF can be concave;
MRT can be falling (if $SE > TE$ for strong IRS) → PPF is convex.



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So, in the long run what will be the final shape of the PPF that depends on the combination of the or the relative strength of the technique effect and the scale effect ok. By technique effect there is no ambiguity by the law of diminishing marginal productivity always MRT is rising you see we have already discussed MRT is increasing because in the expanding X sector MC increases in the contracting Y sector MC falls MRT increases always.

But the ambiguity comes from the scale effect, because we cannot say definitely now under CRS MRT is constant. So, under DRS MRT is rising therefore, combining the with the technique effect what we can see with technique effect and under CRS where MRT is constant MRT will be rising that is by the technique effect.

Under DRS MRT is increasing by law of diminishing marginal productivity by technique effect also MRT is increasing. So, under DRS combining both the things both the laws again MRT will be increasing. Now, if MRT increasing means your PPF will be concave like this because as you are going down you see your MRT increases. So, that is the case under CRS and DRS.

However, with IRS we cannot say definitely what will happen, because you see under IRS now MRT is decreasing and by technique effect MRT is increasing. So, that means, by the technique effect and the scale effect under IRS they operate in opposite direction.

So, what will be the shape of the PPF that will depend on the relative strength of the two effects?

So as long as IRS is weaker so, that the technique effect dominates the scale effect you see if technique effect is stronger than the scale effect for weak IRS, MRT is still increasing and PPF can be concave. So, we can still have a concave PPF with you weak IRS. But if the IRS is very strong then what will happen then MRT is decreasing and if the IRS is strong enough to outweigh the technique effect by which MRT is falling.

So, finally, MRT can be by the technique effect MRT is increasing by the scale effect in case of strong IRS, MRT is decreasing. So, for strong IRS MRT can be decreasing and PPF can be convex. So, what we can conclude over here? Under CRS and DRS, we have no ambiguity. With CRS and DRS, we can say that combining along with the technique effect PPF is concave.

With IRS it is not that always with IRS the PPF will be convex. No for weak IRS still PPF will be concave, but for strong IRS PPF will not be concave we can have a convex PPF like this where MRT is decreasing. This is the case for strong IRS and this is the case for CRS, DRS and weak IRS and of course, you see we have the technique effect, because this one of the final one I am drawing is combination of scale effect and technique effect and even also we can have a straight line PPF is not it.

Because if the scale effect and technique effect they are just equal and we have IRS and so the scale effect and technique effect they are moving in opposite direction, but they are just equal. So, we can also have a straight line. So, here you have a scale effect equals to technique effect and by the scale effect here is we have IRS, but the two magnitude is just same.

So, you can still you can have a straight line PPF also right. So, hence we get the concave shape. So, that means, you see if we go back and we see the assumptions you see we wrote that we have concave PPF under diminishing marginal productivity with non-IRS or even you can add weak IRS.

So, with non-IRS actually you have no ambiguity, you have CRS and DRS of course, MRT will be increasing by diminishing marginal productivity also MRT is increasing PPF is concave, but if you have weak IRS then till PPF can be concave. But for strong

IRS, PPF can be convex also and it can be straight line also if they are just the scale effect and technique effect, they are just outweigh each other.

So, you see that is why I have written non-IRS, so that means, there is no ambiguity under CRS and DRS of course, PPF will be concave.

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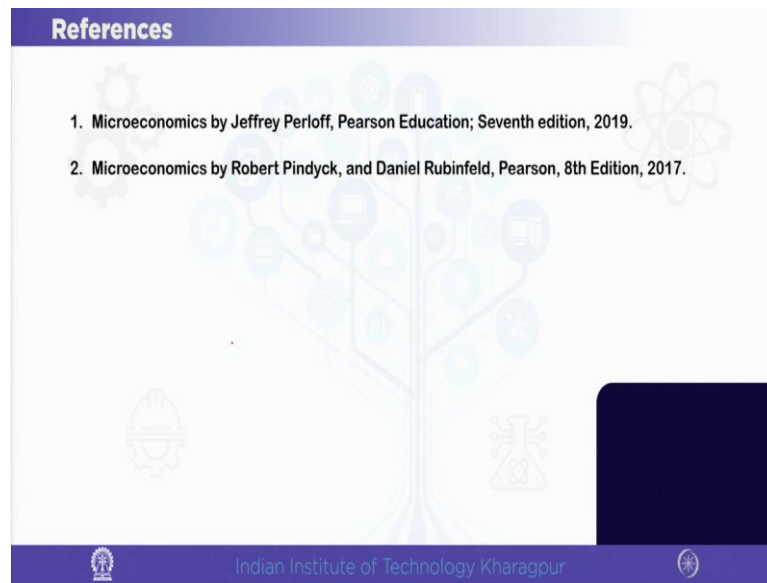
Conclusion

- ❖ What is PPF?
- ❖ How do we interpret the slope of the PPF?
- ❖ What factors govern the shape of PPF?

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So, in today's class we discussed what is PPF we interpreted the PPF, we discussed why the PPF is negatively sloped, what do we call the slope of the PPF and we discussed about the shape of the PPF and what are the factors which govern the shape of the PPF? So, we saw the importance of the 2 laws of production.

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So, once again see you can follow any standard microeconomics book to study PPF. So, only one last thing that I would like to point out that PPF is relevant for the economy as a whole not to a particular firm.

So, with this I finish today's lecture.

Thank you very much.