Environmental and Resource Economics
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Natural Resources Economics and Dynamic Optimization Part - 4

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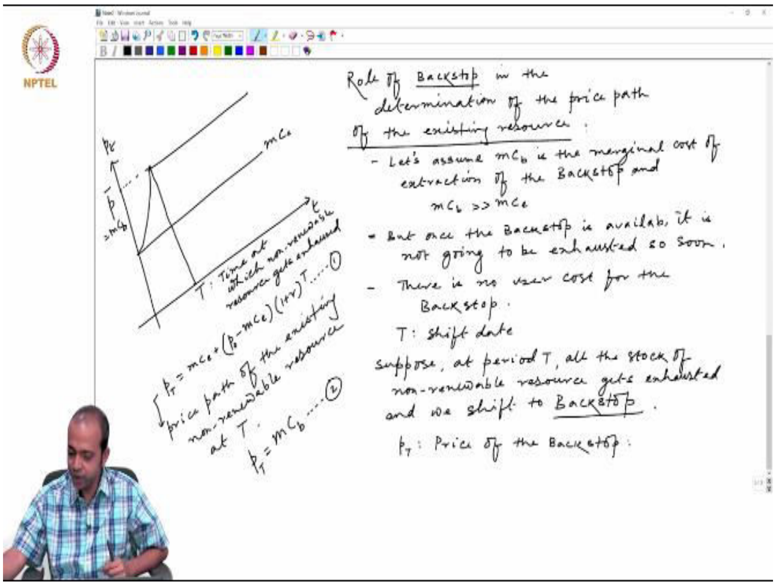

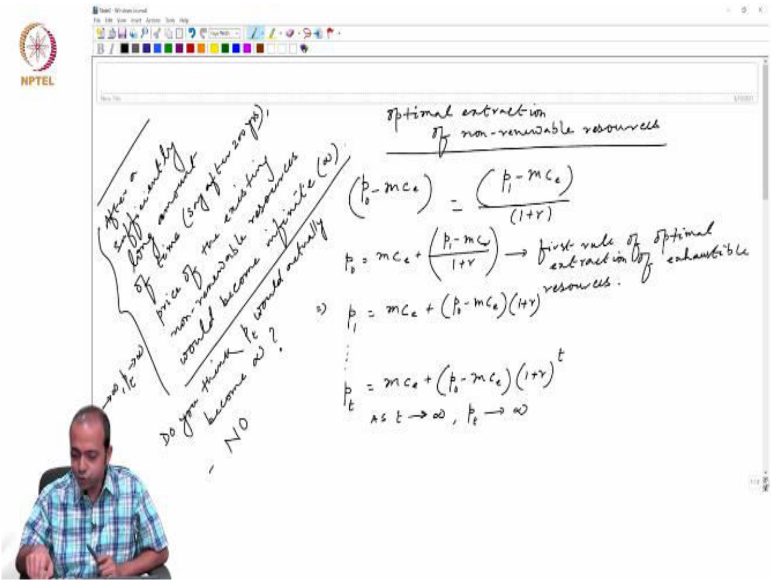

So to understand the role of Backstop, so basically we will now examine role of Backstop in the determination of the price path of the existing resource. Let us assume mcb is the marginal cost of extraction of the Backstop, so in our previous discussion as an example of Backstop we may say that solar energy is a Backstop, and obviously there would be a cost of extraction for solar energy also and what we assume that marginal cost of extraction and mcb is actually quite higher than mce.

So that means what we are saying that marginal cost of extraction of the Backstop is quite higher than the marginal cost of extraction for the existing non-renewable resources. So marginal cost of extraction for coal or oil is much lower than marginal cost of extraction of solar energy, so initial cost of extraction, initial cost of extraction, initial marginal cost of extraction for the Backstop is quite higher, but once the Backstop is available it is not going to be exhausted so soon.

So once we know how to extract solar energy, so obviously it is quite reasonable to understand that solar energy is not going to be exhausted so soon like coal or oil. Solar energy is not going to be exhausted so soon, so if solar energy is not going to be exhausted so soon what is the implication of this, if you compare the renewable energy with this Backstop what is the major difference between these two.

See in the case of non-renewable resources we said that price should be equals to marginal cost of extraction plus a user cost, why this is user cost, because there is a limited supply for this non-renewable resources, if we extract today same amount is not available tomorrow, same amount is not available tomorrow.

But that is not the case for the non-renewable, for the Backstop, if you use the solar energy today, tomorrow also use you can use the same amount of solar energy, it will not get exhausted so soon and implication is that price is only determined by its marginal cost of extraction, there is no user cost because of this. So the implication there is no user cost for the Backstop, there is no user cost.

Now, let us assume that we will draw a simple diagram, let us say that this is in y axis we are measuring price and in the x axis we are measuring time, so this is basically marginal cost of extraction let us say the ordinary resources and for Backstop what we are saying that as time increases, so it is increasing the marginal cost of extraction up to some point but then after that it is flat, it is not changing because you have adequate amount of supply.

This particular point, let us say this is capital T, so this is basically p bar which is actually equals to mcb, the marginal cost of extraction for the Backstop technology. So we assume that T is the time, capital T is the time at which non-renewable resource gets exhausted and once the stock of non-renewable resource gets exhausted we will shift to the Backstop that is the idea.

So T is also you can think of the shift date, so T is basically called shift date, so that means basically we are assuming suppose at period T all the stock of non-renewable resource gets exhausted and we shift to Backstop. So that means what is happening here as time increases, if you look at the behavior of the price, price is also increasing at an increasing rate, why?

Because the stock of existing resource is getting exhausted slowly by slowly, but at time period T after that you look at p is basically fixed, why this is so, because at this point which is basically called shift date we have now alternative resource which is called Backstop, so that is why at this point the price is given by p bar, price is actually set by an upper limit p bar.

Now what we will do assuming that at time period T also some amount of non-renewable resource available we need to determine the price path of the existing non-renewable resource at time period capital T and that is basically given by pT, if you look at pT would become mce plus p0 minus mce into 1 plus r to the power T.

So this is basically price path of the existing resource, existing non-renewable resource at capital T and this equation we are getting simply from our first rule of, if you go back this is the equation pT equals to mce plus p0 minus mce into 1 plus r to the power T. So instead of t we are putting capital T at that point at that shift date when nonrenewable results get exhausted, so what would be the price behavior at that point of tim,e so put just I am putting t equals to capital T, let us say this is equation 1.

And at time period T since non-renewable resource gets exhausted and we shift towards Backstop assuming pT is the price of the Backstop we can simply write pT equals to mcb, so pT is basically price of Backstop and mcb is the marginal cost of extraction for the Backstop, pT equals to mcb this is let us say equation 2, where pT is price of the Backstop.

So this is little conceptual, what I am saying at time period T first we are trying to understand what is the price path of the existing resource so this is coming from the first rule of optimal extraction pT equals to mce plus p 0 minus mce into 1 plus r to the power T.

Second equation tells us that at time period T if we assume pT is the price of the Backstop then that is simply determined by mcb since there is no user cost for the Backstop we have already defined earlier, that is why with mcb we are not adding anything, we are not adding anything since equation 1 and 2 both are actually denoting the price behavior of the resource, we can actually equate equation 1 and 2.

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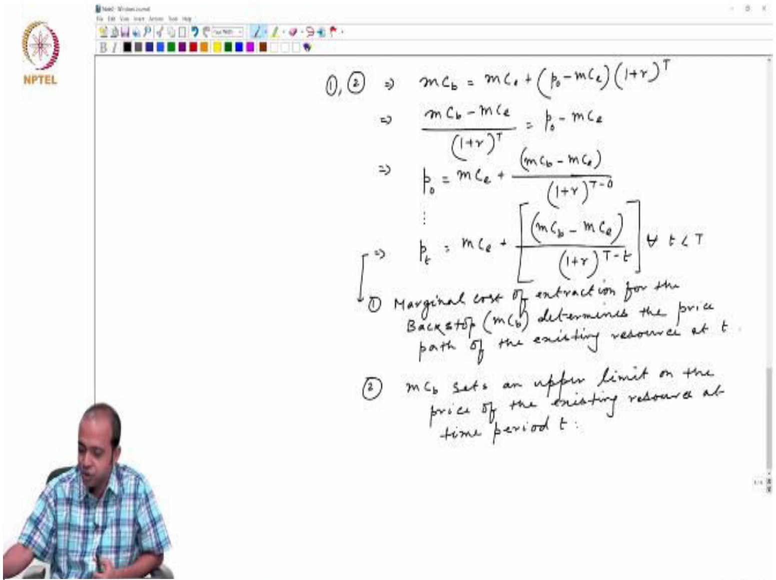

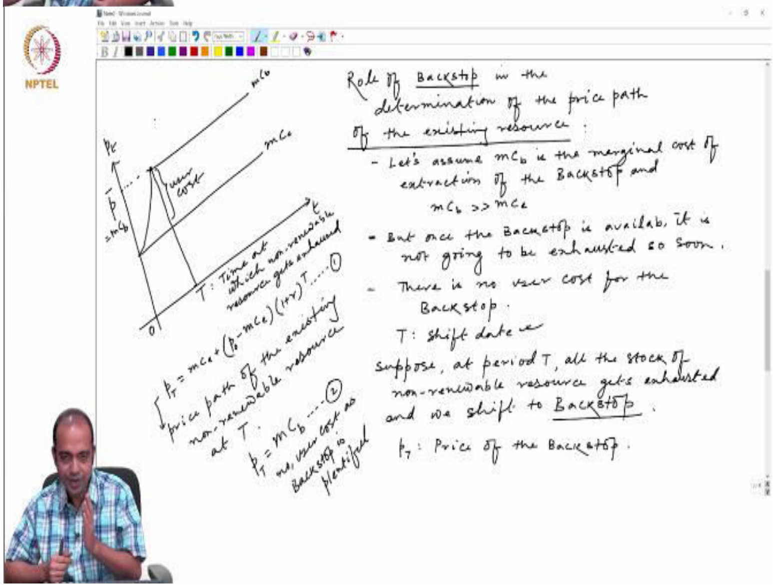

And then what you can get from equation 1 and 2, we can say that mcb equals to, we can say that mce the marginal cost of extraction plus p0 minus mce into 1 plus r to the power T that is all. So from here what we can say that mcb minus mce divided by 1 plus r to the power T equals to p0 minus mce, so that means from here what we can write p0 basically equals to mce plus mcb minus mce divided by 1 plus r to the power T minus 0, I am just instead of T I am putting T minus 0 to have a pattern.

So if that is the case, what would be pT? pT would become mce plus mcb minus mce into 1 plus r to the power capital T minus t, for all t less than capital T. Now this equation is again very insightful and meaningful. What does this equation say? This equation is telling that look at this mcb is actually determining the price of the existing resource as time period t, so that means from here what we can get two insight.

First of all, mcb that means marginal cost of extraction for the Backstop which is mcb determines the price path of the existing resource. What is the implication, that means see here mcb minus m mce divided by 1 plus r to the power T minus t, so this entire thing is basically the user cost. So in the determination of user cost mcb is coming into the picture, so that means how easily or how easily mcb would be available in future that will actually determine the user cost and thereby the price path of the existing resource.

If the Backstop is very difficult to harvest, so if from this equation you can understand if mcb is quite high then pT that means price of the existing resource at time period T will also become very high. If mcb is quite low that means we have compatible technology to harvest the Backstop easily then marginal cost of extraction would be very low and pT will also become very low.

So whatever happens that means mcb is actually determining the price path of the existing resource at time period T and secondly mcb sets an upper limit on the price of the existing resource at time period T. These are the two things we have to keep in mind that even though the earlier equation shows that as t tends to infinite, price of the existing resource pT will also become infinite it is not so, it is not going to be happen so because the demand condition.

And the demand condition is basically determined by the alternative resources that would be available after 200 years or alternative technology which will make the utilization of the existing resource more efficient. Now this equation, from this equation what we basically did I will repeat once again these two equation, equation 1 and 2 while equation 1 is basically determines the price path of the existing resource at time period capital T, that means at shift date, assuming the resource is still available what is the price path.

We assume that t is the shift date when existing resource will get exhausted and we will shift towards the Backstop. How difficult it would be to shift towards the Backstop will be captured by this marginal cost of extraction mcb, that is equation 1. And equation 2 it tells that what is the price of the Backstop, price of the backstop pT equals to mcb, we are not adding anything here no user cost as Backstop is plentiful, so we are not adding any user cost here unlike the existing non-renewable resource, for existing non-renewable resource the resource gets exhausted.

So today's utilization requires an user cost to be added, to be augmented then only we will get the price but here you have to keep in mind that pT equals to only mcb. So that means we can understand that equation 1 and 2 they are actually equivalent both the things, both are denoting the price of the same resource, so then only we are equating equation 1 and 2 and from there by equating 1 and 2 we are getting this pT equals to this at time period capital T.

That means the marginal cost of extraction for the Backstop mcb, this equation clearly shows determines the price path of the existing resource at t and mcb basically sets an upper limit on the price of the existing resource, that is also very true from here. These are the two insights that we can draw from this particular equation and the diagram I will just explain once again in the x axis we are measuring time, in the y axis price.

So initially from 0 to t you can understand the price is increasing at an increasing rate, this is price of the existing resource. Now once the resource gets exhausted at time period t which is called shift date, I have mentioned this is called shift date, Backstop is available and then price becomes flat, then the price becomes flat, so this is we can say that mcb, you can say that mcb is quite high is quite higher than mce because the difference is basically there is a huge difference between mcb and mce.

That is the assumption that marginal cost of extraction for the Backstop is quite high but once it is available then it is not going to be exhausted so soon. So this you can think of user cost mce, so this user cost we are thinking only for the existing resource, this is mce the marginal cost of extraction for the existing resource and this is p at time period t, so you can say that this is the user cost.

But for mcb there is no user cost, p equals to mcb and that is why p we are putting the price of the Backstop is p bar at that ship that it is not changing, it is mcb puts an upper limit given by p bar. So with this we are just closing our discussion today, basically we have now explained rule of Backstop, alternative resources to determine the price path of the existing resource and we have also learned how the Backstop technology or Backstop resources it puts an upper limit on the price of the existing resource, even when it is getting exhausted at shift date. Thank you.