**Environmental and Resource Economics**
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**Natural Resources Economics and Dynamic Optimization Part - 3**

Welcome once again to our discussion on natural resource economics. So in our last class we have basically defined natural resource economics, different types of natural resource economics and then we were mainly focusing on what should be the pricing mechanism for optimal extraction of non-renewable resources and we said that marginal cost pricing is not feasible in the context of non-renewable resources because these resources are not easily replicable, over and above marginal cost we need to add something because of this opportunity cost.

Opportunity cost, why it is arising, because if we use the non-renewable resource today, then the same amount of resource will not be available for tomorrow's extraction. So because of which the opportunity cost or marginal user cost we defined should be added with marginal cost of extraction and both these components, marginal cost of extraction plus marginal user cost taken together they are called augmented marginal cost, so price should be equals to augmented marginal cost.

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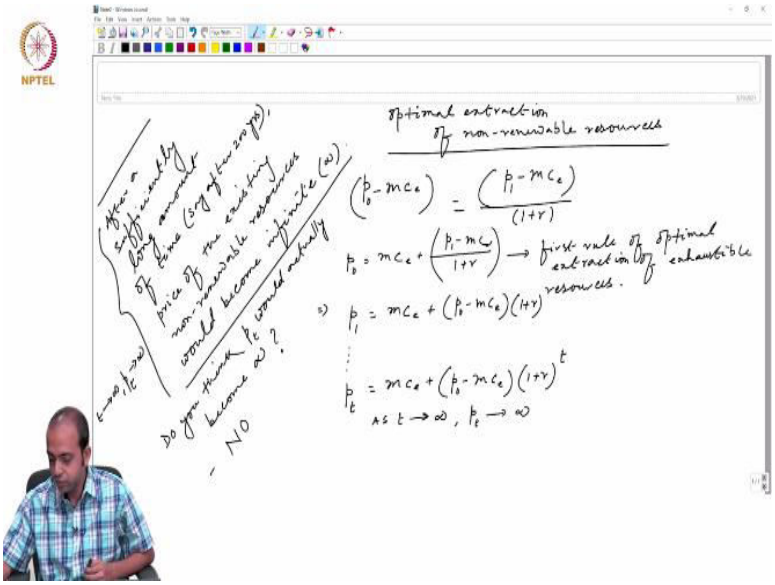


So what we are discussing here optimal extraction of non-renewable resources and our basic framework to decide about the optimal extraction we said that we will assume a resource owner who has some amount of non-renewable resource and the resource owner is trying to

decide whether to extract the resource today or keep it for tomorrow. So depending on the discount rate and expected future price the resource owner will decide how much resource to extract today, how much resource to extract tomorrow so and so forth.

So basically what we discussed is that today's benefit from extracting the resource is p minus this is p, p0 minus mce, p0 minus mce and tomorrow's benefit is basically p1 minus mce marginal cost of extraction and this is the discounted one and at optimality, that means at equilibrium these two conditions, these two benefits are same and resource owner is basically is indifferent between using the resource today or tomorrow.

So from this what we got is basically p0 equals to mce plus p1 minus mce divided by 1 plus r and this is, this condition this is called first rule of optimal extraction of exhaustible resources. So from here what we can get is that from here we can get that p1 is basically equals to mce plus p0 minus mce into 1 plus r and from here what we can get that pt the general expression should be mce plus p0 minus mce into 1 plus r to the power t, so that is the general expression.

Now this equation is quite insightful, from here what we can understand that as t tends to infinity, what will happen? As t tends to infinity p2 or pt also tends to infinity. So that means if we assume a sufficiently large amount of t, that means let us say after 50, 100 or let us say 150 or 200 years, the price of the existing resource will become infinite, so that means there would be an exponential growth for these exhaustible resources, but does it really happen?

Do you think that after 200 years, price of coal or price of one barrel of oil will become infinite? Is it really possible? This equation shows like that, so that means from this equation what you can understand, after a sufficiently long amount of time say after 200 years, price of the existing non-renewable resources would become infinite, that is what we are getting from the fact that as t tends to infinity pt tends to infinity, that is what we are getting.

Now the question is does it or do you think pt would actually become infinite? You have to think, the equation shows like that, from the equation we can easily understand as t tends to infinite then pt that means price of the existing resource at a sufficiently long, after a sufficiently long amount of time it would become pt will tend to infinite. The question is do you think pt would actually become infinite? The answer is actually no, then what are the reasons?

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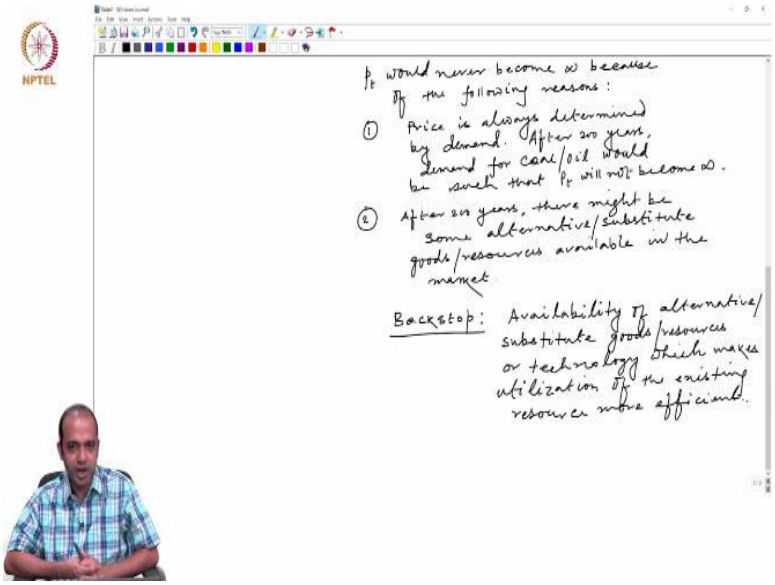


So, pt would never become infinite because of the following reasons. First of all, can you think of what are the two main factors that may explain that pt would never become infinite? See the price, price is always determined by the demand that is very simple demand theory. So price is always determined by demand, so even though this equation shows that as t tends to infinitive pt will become infinite, we have not accommodated the demand condition in that equation after 200 years, so after 200 years, demand for oil, demand for coal or oil would be such that pt will not become infinite.

So we are not sure about the demand for coal or oil after 200 years, unless we consider the demand we cannot say that in finite, so demand will always put a cap on the upper limit of the price, that is very simple, for any good, the demand condition will not allow price to become infinite.

So what we are thinking that after 200 years when the coal or oil the existing non-renewable resource will tend to be almost exhausted because of its lower availability, the price would become infinite. So we are basically thinking only the supply side of the story, since the resource will get exhausted after 200 or 250 or 500 years, the price would become infinite, but we cannot actually decide the price unless we accommodate the demand condition in the model.

So the demand condition will always put a cap on the upper limit of the price, so that is why price will never become infinite. Second reason is after 200 years there might be some alternative or substitute goods or resources available in the market. After 200 years we may

get some alternative of coal, we may get some alternative of oil, so that will heavily influence the utilization of the existing renewable resource.

So that means this alternative will also determine the upper limit of the price and the alternative resource, technology or goods what we are talking about it has a different name, a specific name is given in the resource economics literature which is called Backstop, which is called Backstop.

So what is Backstop basically? Availability of alternative or you may call it substitute goods or resources or technology which makes utilization of the existing resource more efficient, that is the idea of Backstop. So that means after 200 years there might be available alternatives in the market which will influence the demand or there might be availability of alternative technology which will make the utilization of present resource more efficient.

With the given technology the utilization of coal or oil at present time might be quite inefficient that is why we are using too much of coal or oil to produce a given amount of output but it may so happen the technology would become so efficient that we do not require actually that much amount of coal energy to produce the same amount of output that is called technological advancement which will make the utilization of existing resource more efficient.

So either alternative goods or resource or technology these two are known as Backstop in the literature of resource economics, Backstop. Now how this Backstop actually determine the price path of the existing resource that is something we need to understand, how actually it will work.