Energy Resources, Economics and Environment
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Lecture 14

Externalities

We have looked at the difference between private goods and public goods and we have also seen that the market typically under provides public goods, we also looked at the Lindahl equilibrium is one way of trying to see how one can price public goods. But of course, we saw that there are practically, there are difficulties in there.

Today we will be talking about externalities and that is in a production function or a consumption function of any individual or company, if something else well which is not within their control comes into it and affects the production or the consumption utility and So we will define what is an externality, try to see how to analyze it and see what are the ways in which we can incorporate it into the economic calculations.

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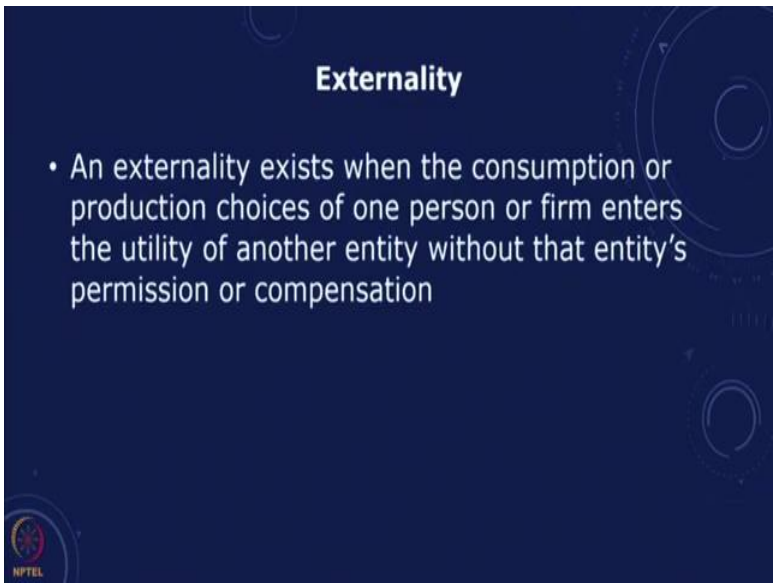

So, a definition of an externality, you can look at any textbook and you will find similar definitions. This definition is from Kolstad, an externality exists when the consumption or production choices of one person or firm enters the utility of another entity without that entity's permission or compensation.

So, please remember the critical point is that, if some variable enters the consumption or production choices without the permission or compensations, so in case two companies have

an agreement and there is a transfer of an output of one company to the other company, that would not be considered an externality.

But when something comes in, which is not within the control of the company and without the permission of that company, then it becomes an externality. So, let us look at, in the public domain, there are a number of cartoons which illustrate negative and positive externalities.

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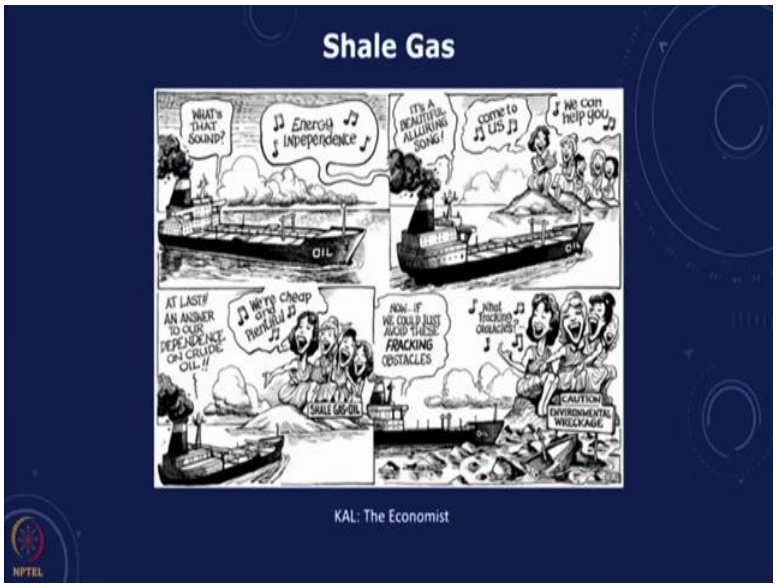

This cartoon is from the economist and it is about Shale gas and as you know, in the oil sector, the Shale gas had the potential to transform the oil sector and it has actually resulted in some countries for instance, the US which was a net oil importer, has now become an oil exporter and this cartoon shows there is, in Greek history there is this concept of there were these sirens who were an attractive set of who with their singing would attract ships and these ships would get then stranded and destroyed in these rocks.

And this was there in the legend. So, in a similar fashion, this cartoon basically shows that when you are trying to get Shale gas, the difficulties, the environmental impacts of fracking and fracking is the process of extraction of Shale gas which involves horizontal drilling, the environmental damage in terms of the water usage and the other damage which is created to the environment because of Shale gas is one of the obstacles in the part of Shale gas.

This is actually the reason why in India, though we have some Shale gas resources in parts of the country, which are actually water scarce and then that is why we have not been focusing on extracting that Shale gas. That is a negative externality.

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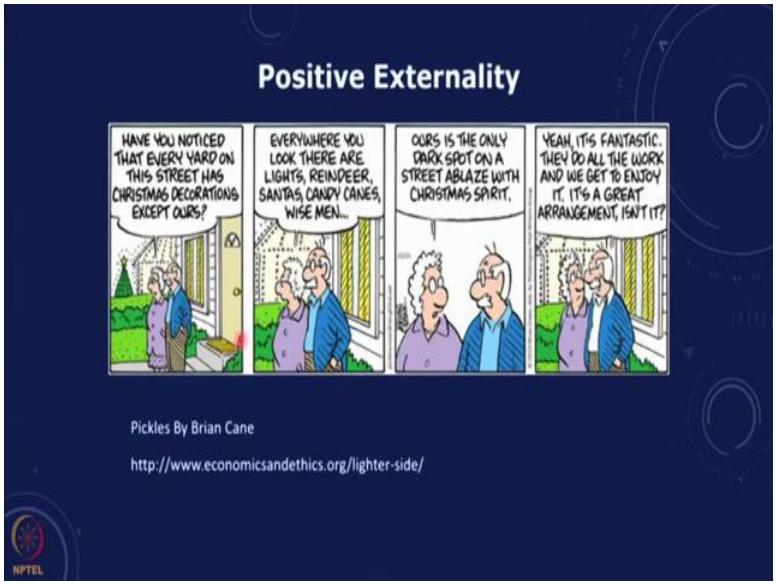

In the case of a positive externality. This is from Dennis the Menace and you can see Mr. Wilson, his wife tells him that have you noticed that every yard on the street has Christmas decoration except ours? Everywhere you look, there are lights, reindeer, Santa's, candy cakes, and ours is the only dark spot on the street ablaze with Christmas spirit and what Mr. Wilson takes this on as a positive externality in the sense that yes, it is fantastic.

They do all the work and we get to enjoy. It is a great arrangement, isn't it? So basically, even if you think in terms of in Diwali, if people are lighting up their homes and putting kandils, and if you are not making that effort, but you are getting the benefit of that effort by seeing, then that becomes a positive externality.

In the similar fashion if some people maintain some very good gardens, and they are putting in efforts to do that, people who are in the neighborhood, who are not putting in that effort are getting the benefit of it and that is a positive externality. In most of the cases when we are talking of environmental economics, we are usually dealing with negative externalities.

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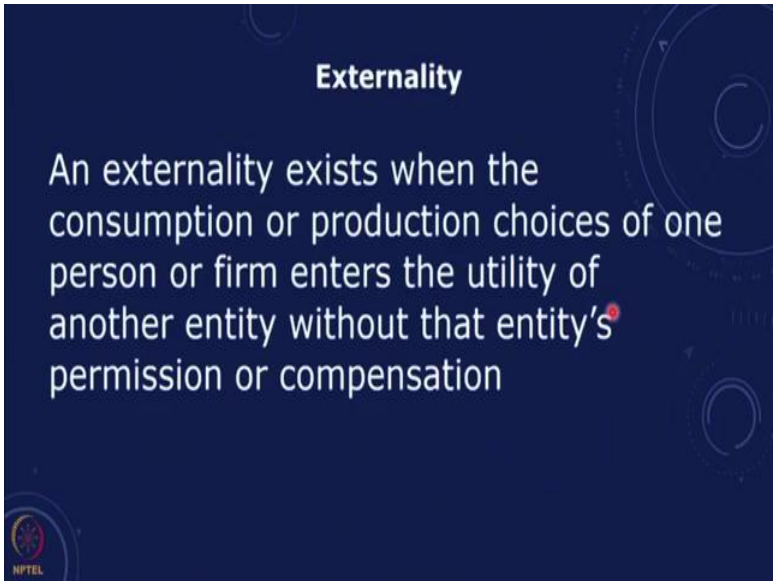

So again, to repeat after looking at these two cartoons, we again repeat the definition where we seeing that basically, whenever a variable enters the utility of another entity without the entity's permission or compensation.

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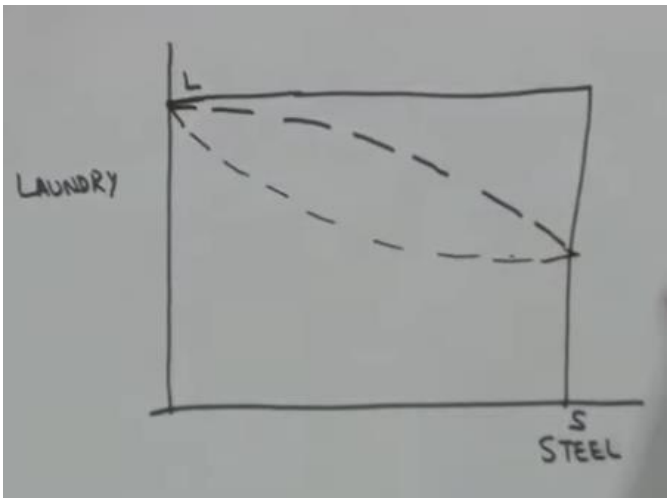

So, let us look at the example and this is from Kolstad. Let us say that there are two factories, there is a steel mill which is producing steel and in the neighborhood there is also a laundry. So, let us look at what is the, here we are looking at steel production and here we are looking at laundry.

So, based on the capacity of the steel mill and the laundry, we can maximum produce a certain amount in the laundry. So, this is the maximum amount and for the steel plant, let us say, so

you have this rectangle where if both if they do not affect each other then you will get this value L and this is the value S.

And this is, but the fact is the steel in the process of making steel, we have some emissions and the pollution, the air pollution which is there, that air is coming to the laundry, when you look at the laundry, it is drying the clothes using steam and it is taking the air which is there, it depends on the humidity and the composition of the air. The exhausts of the steel plant pollutes the air and because of that pollution, the laundry output decreases.

And so, this is a negative externality that it could happen in the following forms. It could be, this is like a modest or weak externality or it could be a strong externality, where production is affected in this fashion. So, if you see, as the quantity of steel being used increases, the output of the laundry decreases and so as a result of the steel production, despite the laundry not actually planning for it, the output gets affected and instead of L, we are now only able to produce a certain smaller value as this S curve.

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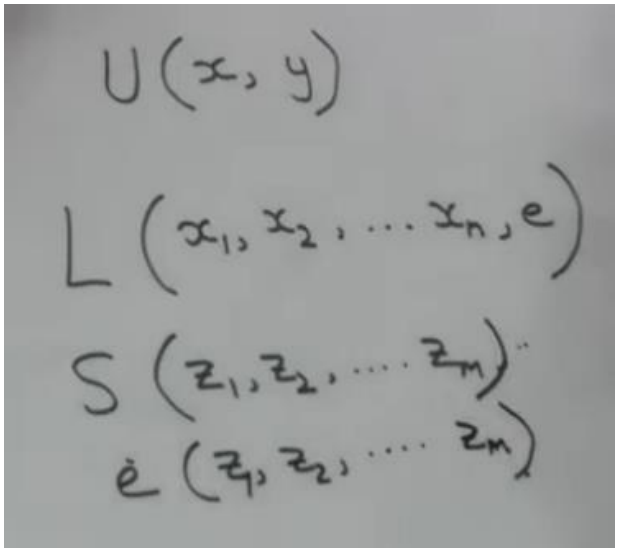

So essentially what happens is in an externality you can see this. In an externality we are saying that if we take an entity with a utility function U as a function of x and y, x are all the input parameters that it controls and it plans for, y is a parameter which is coming from outside, which the entity does not have control over. So, for instance, if the laundry has a production function like this, which says L x1, x2 to xn and e, where e is the emissions occurring because of the steel factory.

So, this is an externality, this affects the laundry production and we saw that for the steel plant, this is, S is z1, z2 and so on, zm and then the value of e which is created, e is also a function of z1, z2 to zm. So, the externality which is created is a function of the amount which we are, the value of S and we get a certain emission factor which is coming out.

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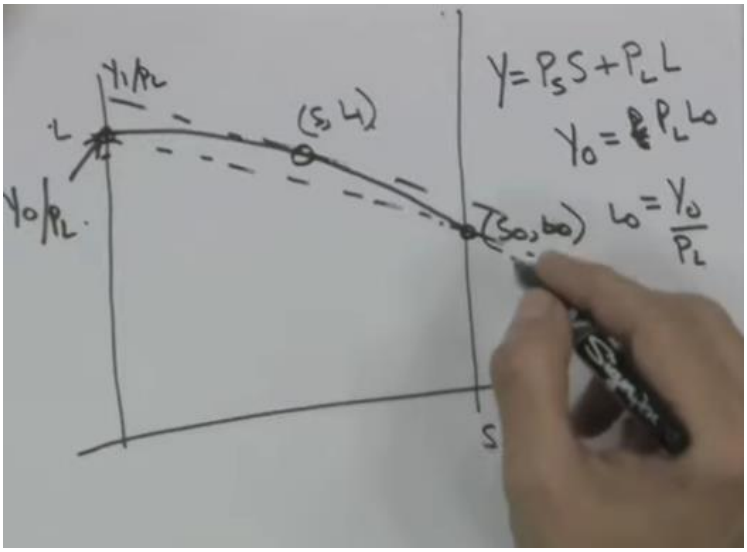

So now, if we look at this, this would mean that if you look at now the effect which is happening, we are seeing that let us say that, let me start with S and L and then we have something like this. So, if you look at this, because of the externality, the points that we can now operate, we can have maximum we can get the output now from the laundry is here and if we look at this, we can operate either at this point or at this point where we have a maximum amount of steel production and certain amount of production in the laundry.

And in this case, what would happen is that, if we look at the cost function, the total revenue which is the price of steel into production of steel, price of laundry into production of laundry, for this, this is a line with the slopes related to the prices and if you look at this, if S is equal to 0, what we get is y0 is PL into the value of L0.

So, L0 is y0 by PL and this is this point, this point is y0 by PL and we will get curve which goes through, this is the revenue function. Now, suppose we want to remove this externality. One possible way of doing that is to say that let us say that the same company owns the laundry and the steel mill or the steel mill buys the laundry in which case, this now does not remain an externality.

It is a decision that, you can change the factors z1 to zm, so that the emission changes and because of the emission, the laundry changes, so the laundry output would change. So, what we can now do is we can get a line parallel to this and we will get a new point which is S1, L1 and obviously the revenue here is going to be higher than the value that we had. So, this is now y1 by PL and so essentially what we get is we are maximizing the revenue. Now this no longer remains an externality, this is internal, the emission becomes internal to the company.

So, this is one way of removing the externality, thinking in terms of maximizing the total output of the laundry and the steel mill and we can compare this and then see how much is the overall loss between these two, the laundry and the steel mill. But if they are separate, we can then compute that this is the loss in revenue of the laundry caused by the externality and based on this. So, this is a sort of simple example to illustrate the impact of the externality.

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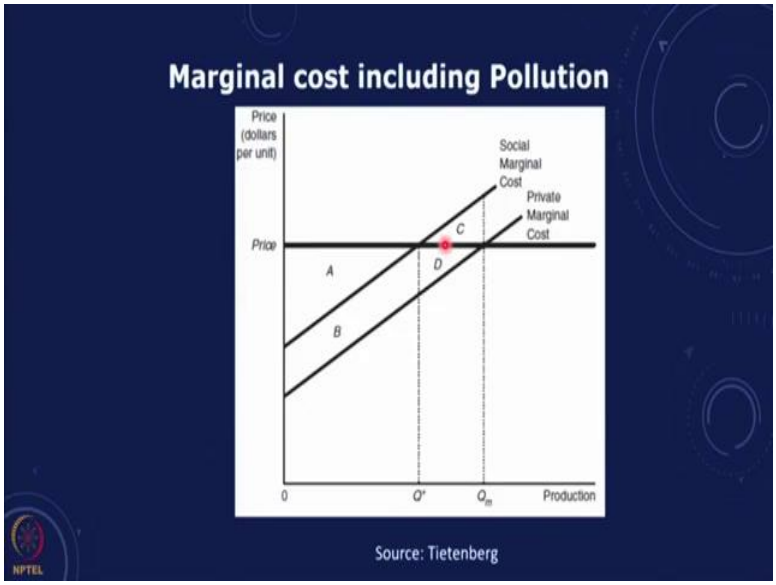

In many cases, when we talk about externality, when we look at our marginal costs, we have a private marginal cost, which is not looking at the impact that it is having or the adverse impact it is having on society. If we add to that the marginal cost of pollution, we can get another curve which shows the social marginal cost. Now, this was we were talking in terms of this in terms of an externality caused by the production function, let us think in terms of the externality cause due to the utility or the consumption function.

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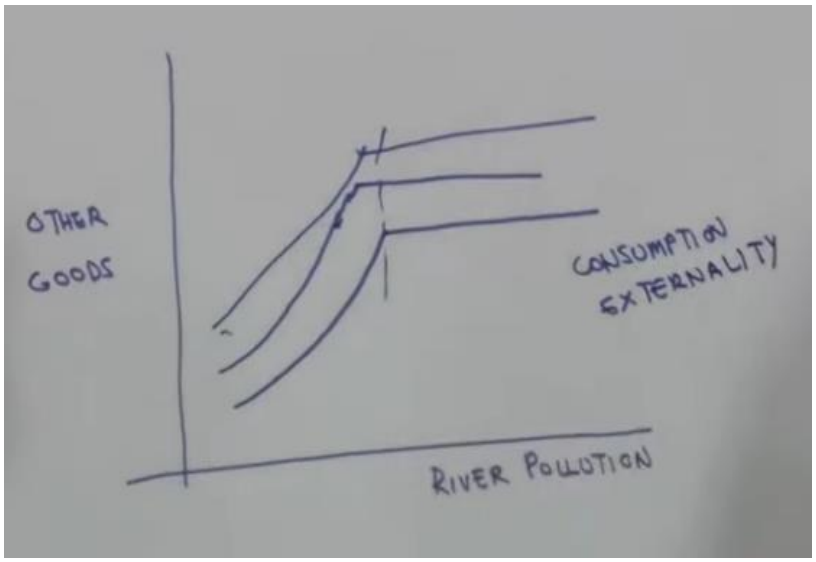

So, let us consider an individual and let us look at river, an individual who has not given a utility function, and that utility function has a combination of different goods and then what we are looking at, is the total amount of, if you are looking at the amount of goods which is being

other goods, which is being purchased, we are looking at individual, who is getting some utility from swimming, and utility from other goods, and then what happens is as if the river pollution increases, then the utility or the benefit that you get from swimming starts decreasing.

So, with the result that to have the same amount of utility, you must have other goods to compensate for it. So, you will get a curve like this for this constant utility, if we are looking at an indifference curve, if this goes to this point. If this goes to a point where the river is so polluted that we would not, there is no utility to be gained through swimming, which would mean that the utility function will become a horizontal line. So, this is a particular indifference curve and then you would have another indifference curve which is parallel to this, going up to here and then, it should come up to here.

It should basically, you will see that it comes up to here and then this. So, this is another way of looking at the indifference curves and then this is the consumption externality, consumption externality caused by river pollution and that pollution could be done maybe by the steel mill that we were talking about.

And so, the question is that, of course, we can convert this into an economic term by looking at, let us say a holiday resort, where it gets a revenue based on swimming and then there is a steel mill which is polluting the river and because of that, the revenue of the holiday resort can decrease and we can quantify this kind of an impact.

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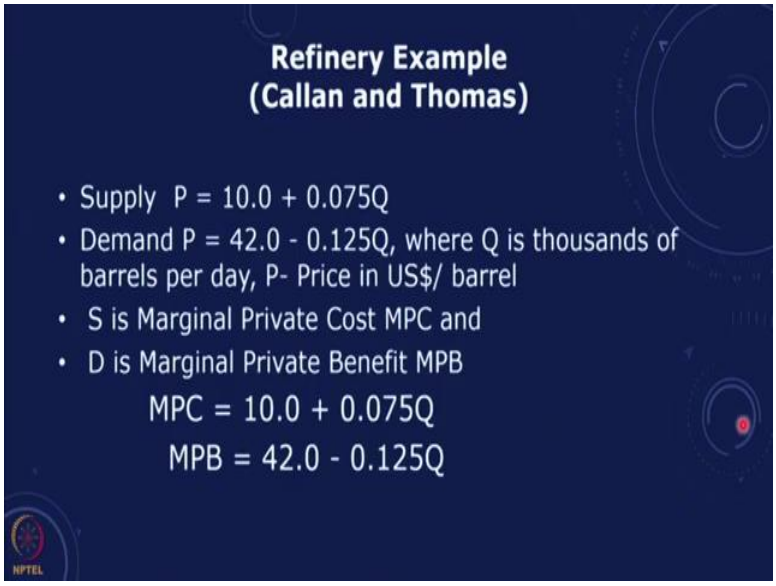

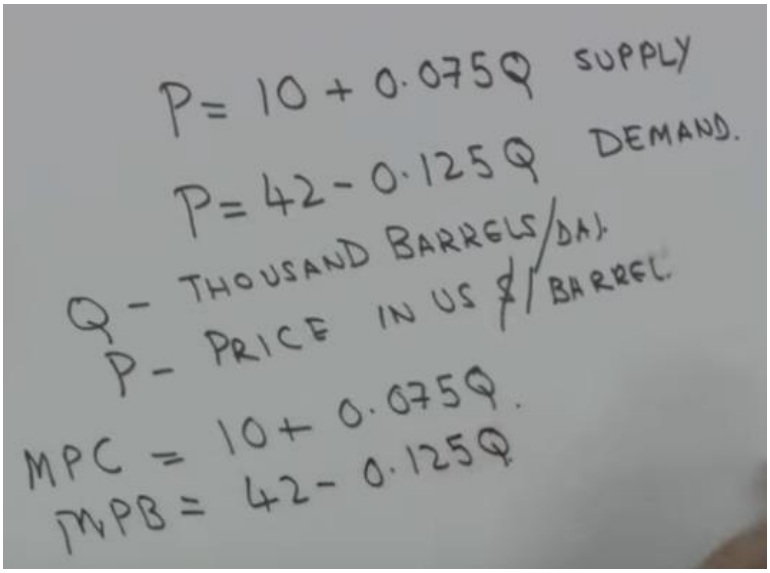

So, in a sense, we have shown some simple examples, hypothetical examples of production externality and consumption externality. Now let us look at a simple example and this is from the book by Callan and Thomas. And we have two characteristics supply and demand curves. the price this is for a refinery. The price is given as 10 plus 0.75Q, we are just following that example. So, we will use the units.

This is the supply units given by the example in Callan and Thomas and the demand is P is 42 minus 0.125Q where Q is thousand barrels per day and P is the price in US dollars, US dollars per barrel. So, let us look at the supply which we are talking of. This is also the marginal private costs. So, this can be, we can write this as the marginal private cost is going to be 10 plus 0.075 Q and the marginal private benefit is 42 minus 0.125 Q.

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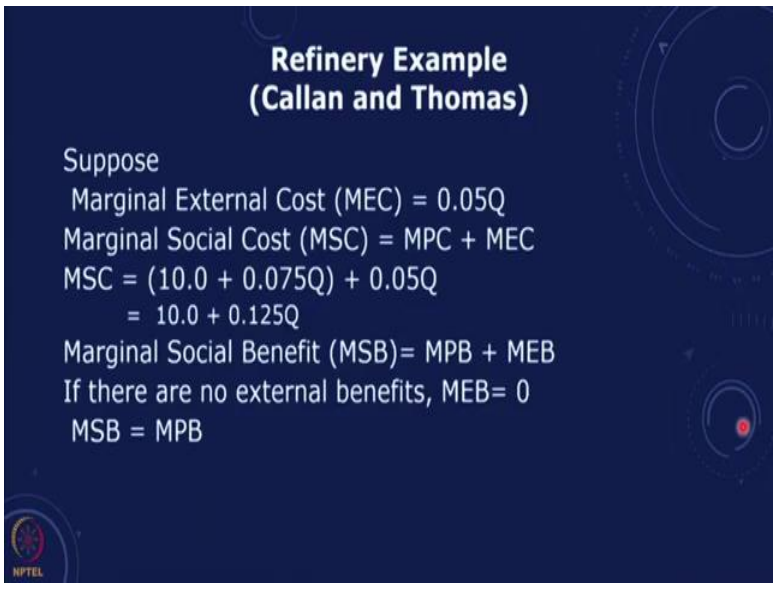

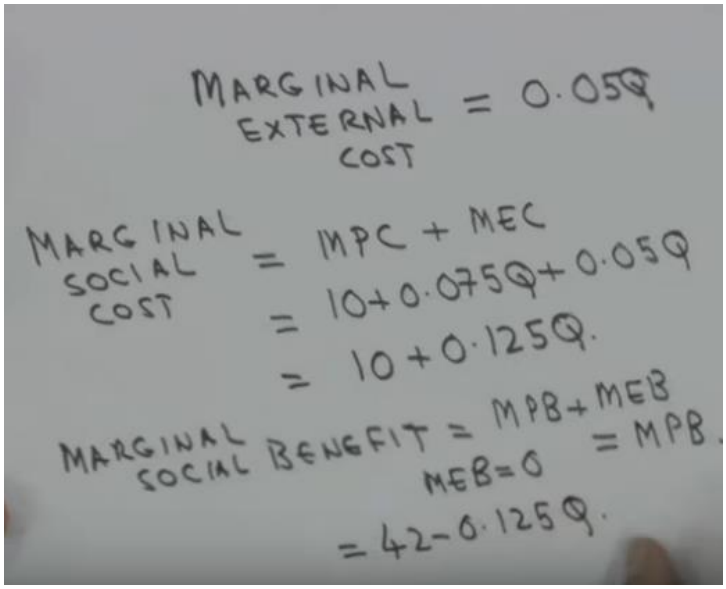

Now, we can take this and draw. So we can look at drawing this, suppose, there is also a marginal external cost, marginal external cost is given as marginal external cost that means, for every barrel that is processed in the refinery there is a certain amount of pollution and that pollution is we assign a cost to it and that is cost which the refinery has to pay maybe as a tax, as an environmental tax to the society and that is given as 0.05 Q.

So, if marginal external cost is 0.05Q, then the marginal social costs, social costs, this will be the sum of the marginal private costs, which is the cost to the refinery plus the marginal external cost that means, see now we have put a value to the externality.

The externality is because the refinery is affecting the utility functions of the society. So, we can do this and then the marginal social cost will be 10 plus 0.075Q plus 0.05Q and this comes out to be 10 plus 0.125, 75 plus 5, 0.125 Q. What about the marginal social benefit?

Marginal social benefit, this will be equal to marginal private benefit plus marginal external benefit. So, in case there was a positive externality, this is what would have come. Now here MEB will be equal to 0. So, this marginal social benefit is equal to marginal private benefit which is nothing but 42 minus 0.125 Q. Now, let us look at the equilibrium that we get.

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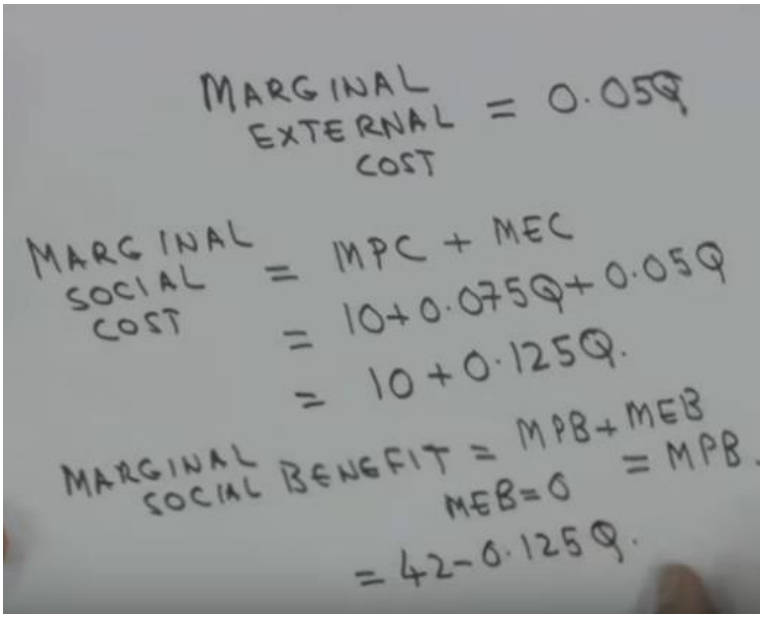

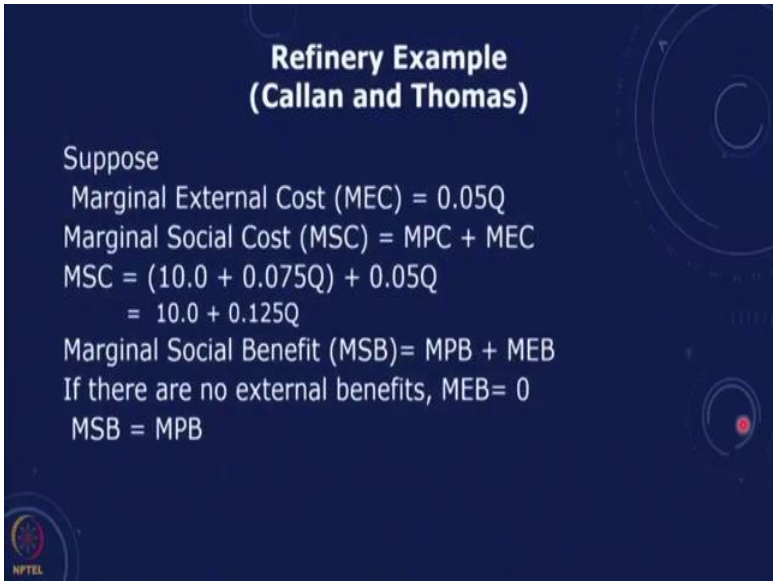

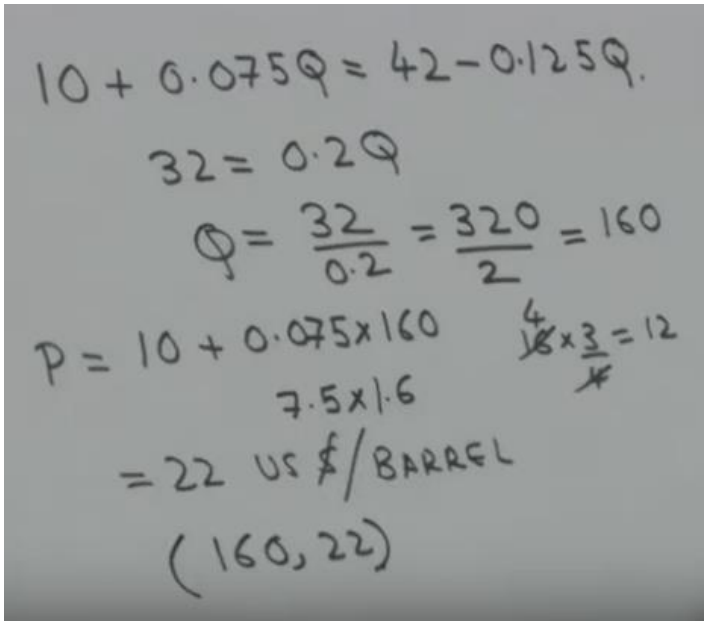

So, what happens here is if you see we had written this marginal private cost and marginal private benefit and if we do not consider the externality, which is the normal situation, where we are just looking at the equilibrium between the private cost and benefit and then this is going to be, we can equate the two, 10 plus 0.025 Q is 42 minus 0.125 Q. So, we get 32 is equal to point, this comes here 0.25 and 0.75, so you get 0.2Q and Q becomes equal to 32 by 0.2. So, this is 160 and this is the 1000 barrels per day.

Now, let us look at what is the price, price is going to be equal to 10 plus 0.075 into 160. So, this is 160 if you see it is 12, 7.5, 12 into 1.6, it is 10, 16 into three fourths that is 12, 12 plus 10, this is 22 US dollars per barrel. So, we got the equilibrium which is going to be 160 and 22.

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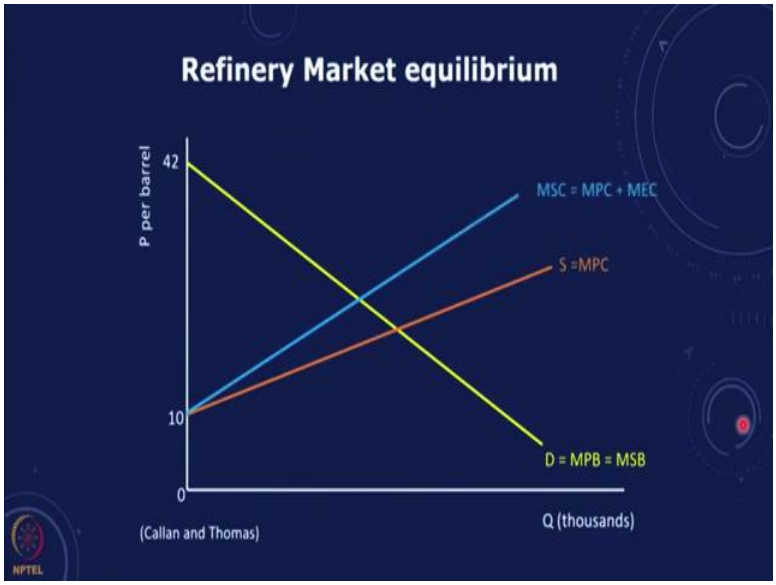

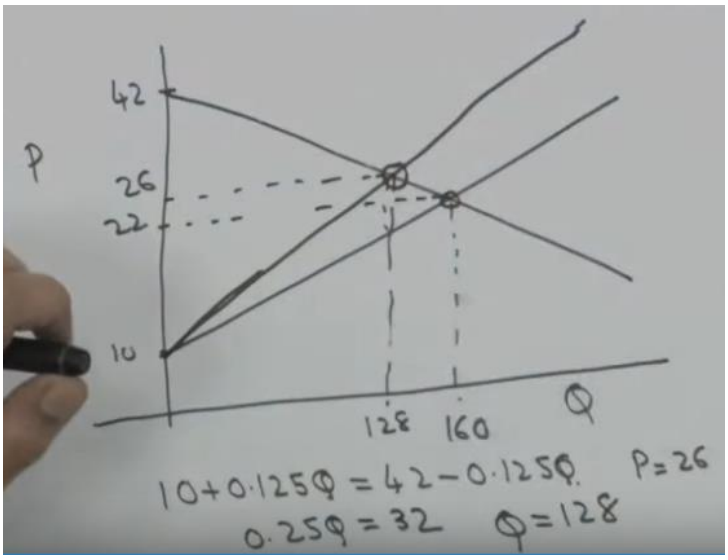

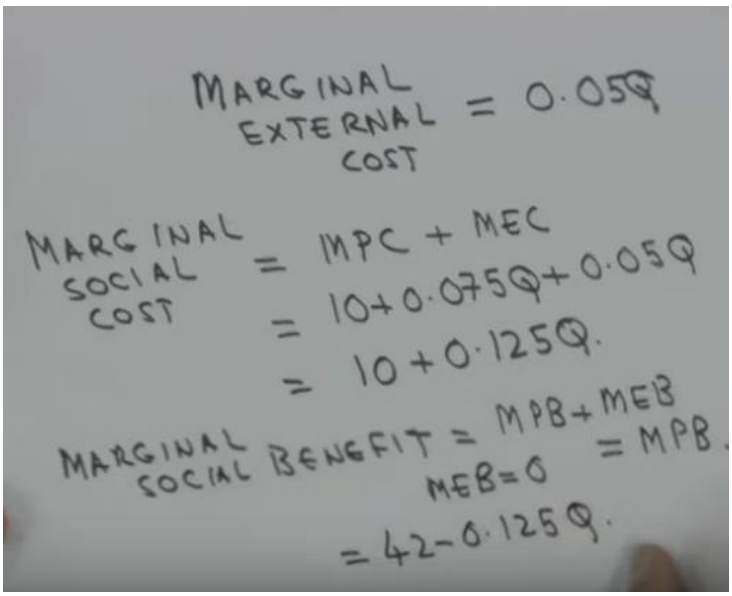

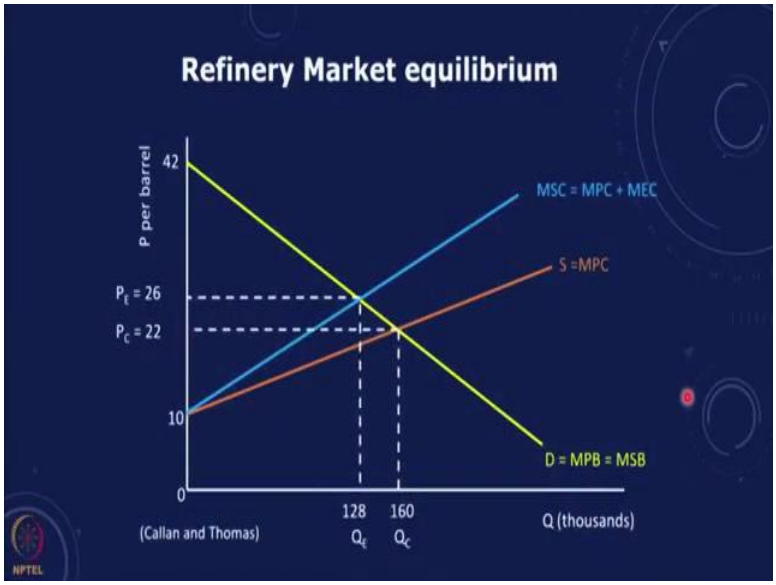

So, if we draw this sketch this now, you can show this as this way and you will get, we get this value 160 and 22. Now, what happens is that we can sketch it like this. We get this as 10 and this is coming from 42 onwards. So, this is 42 and this comes down here and here you have 10. This is the price and this is the quantity in 1000. This is the price and we get an equilibrium which is here, which is 160, this is 22. Now, what happens is we want to now put the, if you remember we brought the marginal social cost and that marginal social cost we had calculated that as, added to that the external cost.

So, we got the marginal social costs as 10 plus 0.25Q. So, then the slope, this slope changes, it starts with 10 but it will… So, as a result of this what happens is because now we are taking in additional costs, the optimal equilibrium point now shifts, the price increases and the quantity decreases and as a result of this what happens is that we are now reducing the total amount of quantity, we are also reducing the pollution which is happening in the society.

So, if you see this, in this curve you see that this is what happens and we can make that calculation because now what we have is it is 10 plus 0.125 Q is equal to 42 minus 0.125 Q. So, what we get is 0.25 Q is equal to 32 Q becomes equal to 128, 128,000, you can substitute that back in the price and you get price now is equal to 26 dollars per barrel. So now this point which is there is 128 and this is 26.

So, with the result now, what happens is in the initial case we had maximized, we have the consumer and the producer surplus being maximized. However, we had not taken the externality into it. Once you shift this, there is a social cost which was there which we had not considered.

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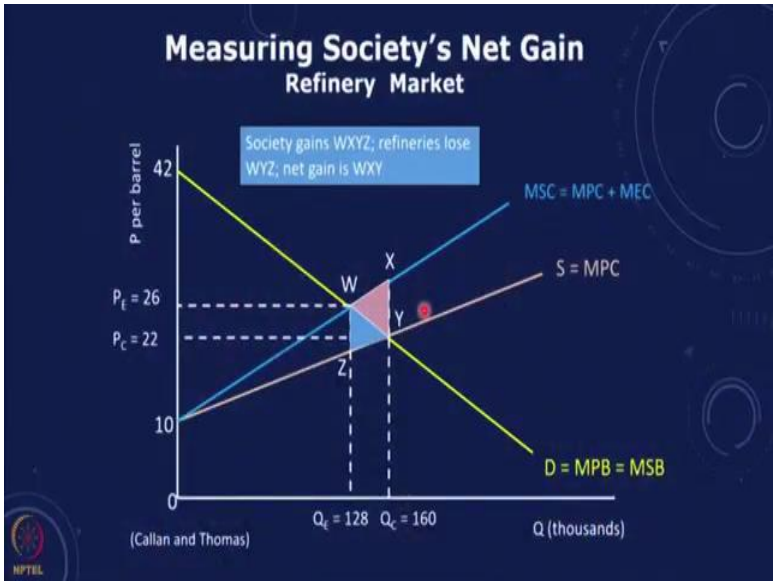

If you look at this now, we are measuring up, if you look at the society is net gain in the refinery market and this is again from the Callan and Thomas example, you see that these are the equilibrium points. If you look at these points, you will find that there is a net, the society gains this trapezium WXYZ. WXYZ is the society's gain. The refineries are losing XWYZ. This is loss, this is the loss in the overall surplus which was there and because of that now the net gain which is there is just WXY.

So overall what is happening is that we can be, if you don't consider the external cost and the social cost as compared to that the refinery is losing, there is a net loss in the surplus. However, the societal cost, when that is considered the externality that is the impact to society that is decreased now because the pollution is decreased, the quantity is decreased and that offsets the loss which is incurred by the refinery.

And because of that, the overall it makes sense to quantify and to cost the externality and to put a price on the social cost. Of course, this is easier said than done. What is the appropriate price and this but you can see that by doing that, the equilibrium shifts and, so this is one way in which we can deal with the externalities.

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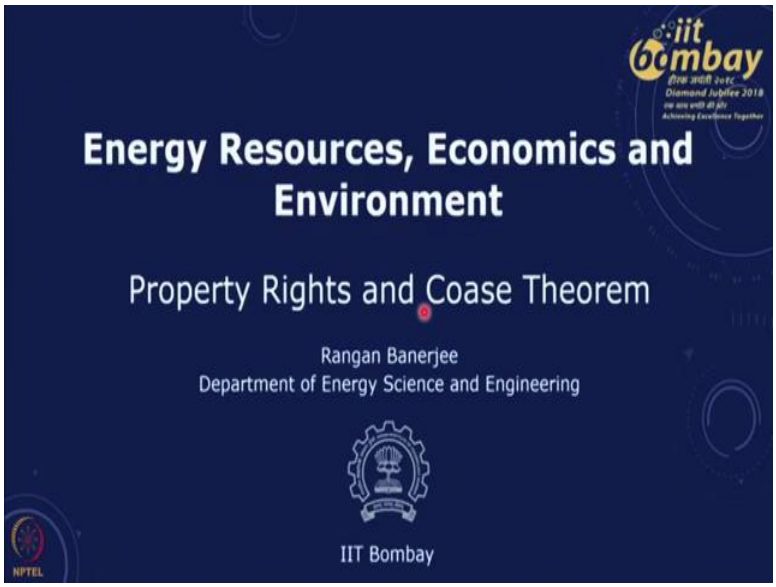

You can look at more details in the three books by Kolstad, Tietenberg and Callan and Thomas. Now we would like to look at a related issue. When we talk about the externalities, we need to think in terms of property rights, and the property rights and the Coase theorem are related issues and we will just briefly touch upon this.

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So, property rights when we talk about property rights, it means that if you have some goods and services, you have property rights on that. This is enforceable, so that means, if someone steals your cell phone, you can make a complaint to the police and get it back and so stealing essentially is illegal, you have the property right over your goods and the services that you have procured. If this is not there, the goods could not be excludable, could not be used in the market, cannot be rationed using prices.

So, for instance, take another example of a private badge for instance garbage, if there are no laws to prevent littering, then garbage would not be considered to be excludable and then there would not be any property rights in terms of the garbage because any garbage can just, you can just throw it wherever you want and then then there is no issue in terms of… However, if there are strict littering laws, then you have to dispose off the garbage. You own the garbage, that disposal, you will have to incur some costs in doing the disposal.

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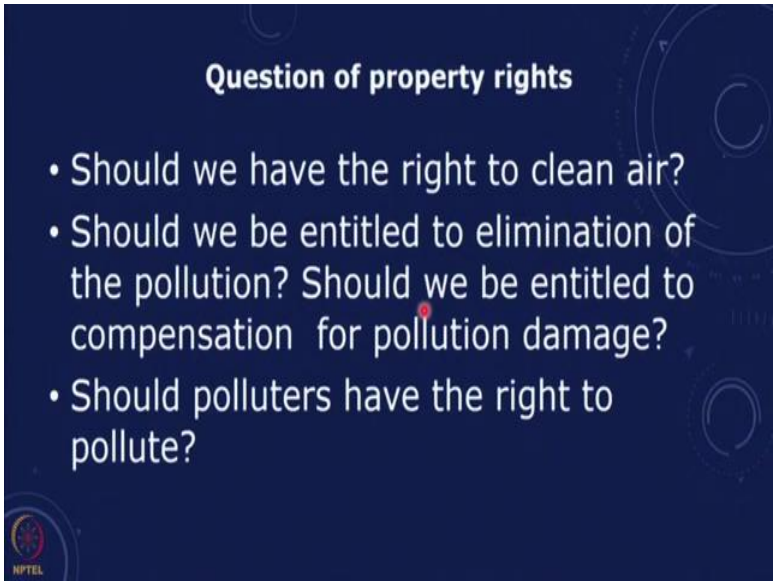

So, now the question of property rights is, in the case of environment, these are important. So, who has the right? If there is a factory, there is a steel mill, does the steel mill have the right to pollute and release emissions to the air? Should we have the right to clean air? Should we be entitled to elimination of pollution? Should we be entitled to compensation for pollution damage? Or should polluters have the right to pollute? And this is an interesting question.

There is an ethical questions related to these questions of fairness, questions of justice. But the interesting thing is from an economic viewpoint, Ronald Coase provided an interesting argument, which is a little counterintuitive, and essentially, the argument says that from an economic viewpoint it does not matter who has the right. Whether the society or the citizens have the right to clean air, or the industry has the right to pollute, the final optimum economic optimum remains the same.

And so that is a very interesting and the example Ronald Coase paper talks about a number of different examples. It talks about the example of farmers raring cattle and the straying cattle affecting the farmers crops and then another example where there is a tall building blocking the air currents of a wind turbine. So, the wind turbine output gets affected by the building.

So, the question is whether the building has the right to do that, or the wind turbine has the right to have a free space and the building should get permission from the wind turbine or should compensate the wind turbine manufacturer. A building casting a shadow on a cabana and swimming area in the sunbathing area of a hotel and resulting in a loss of revenue to the

hotel and then, so then there are these airport coming in a particular location and affecting the residents and the noise and then there were many different cases which are there.

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So, Ronald Coase discusses and looks at legal judgments in many of these cases and the question being raised is who should have the rights? The polluter or the victim? For instance, we talked about the steel factory or the laundry and then we said, if we combine them, we get an optimal but who has the right? Does the steel factory have the right? Or the laundry has the right? And the laundry has the right to clean air then the Steel factory will have to compensate.

If the steel factory has the right to pollute because maybe it was there before and then the laundry will, then it would not give any compensation. A refinery or a car factory, again the refinery affecting the output and polluting and affecting the car factory, steel factory or a hotel, refinery or recreational users and these are all from different textbooks and Ronald Coase paper talks about a doctor and a confectioner.

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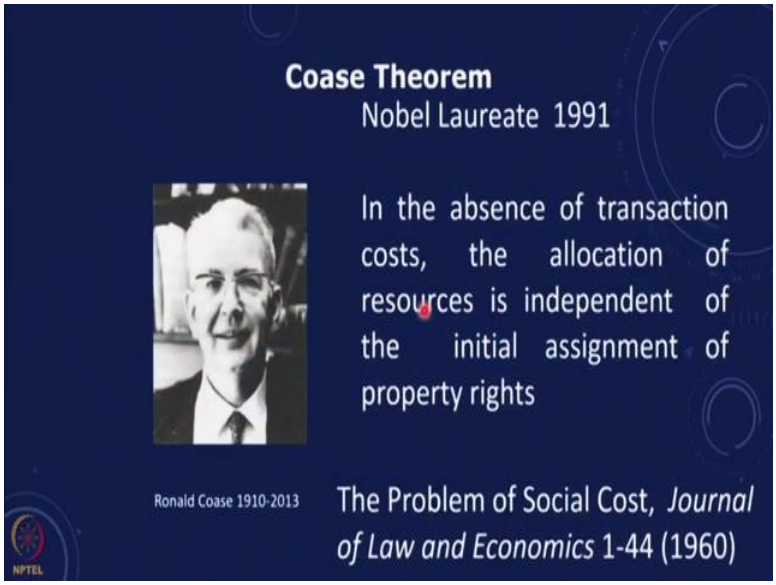

So, Ronald Coase proposed the Coase theorem and got the Nobel Prize in 1991. This paper was published in 1960. It is called the problem of social cost. It is in the Journal of law and economics and you can look up the original paper and his theorem, the Coase theorem says in the absence of transaction costs, the allocation of resources is independent of the initial assignment of property rights, which means that if there are no transaction costs involved, then it is immaterial who has the rights, whether the polluter or the victim has the rights and the result, we would get the same economic solution.

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And so, the proper assignment of property rights, even if externalities are present will allow bargaining between parties such that an efficient solution will result regardless of who holds the right and this assumes costless transactions and it assumes that damages are accessible and measurable.

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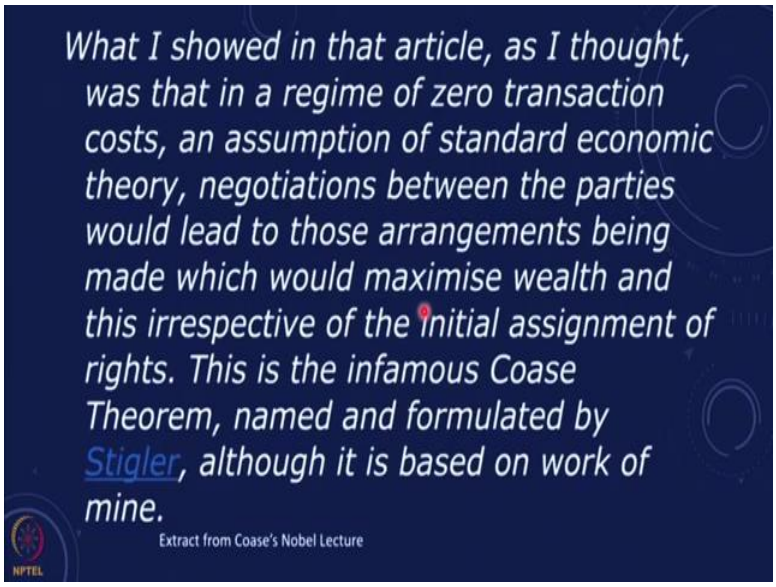

So, in Coase's own words, he says that what I showed in that article as I thought was that in a regime of zero transaction costs and assumption of standard economic theory, negotiations between the parties would lead to those arrangements being made, which would maximize wealth and this irrespective of the initial assignments of rights. This is the famous Coase theorem named and formulated by Stigler, although it is based on work of mine. So, it was Ronald Coase who gave this, who did this, but it was articulated as the Coase theorem by another famous economist who is this, Joseph Stickler.

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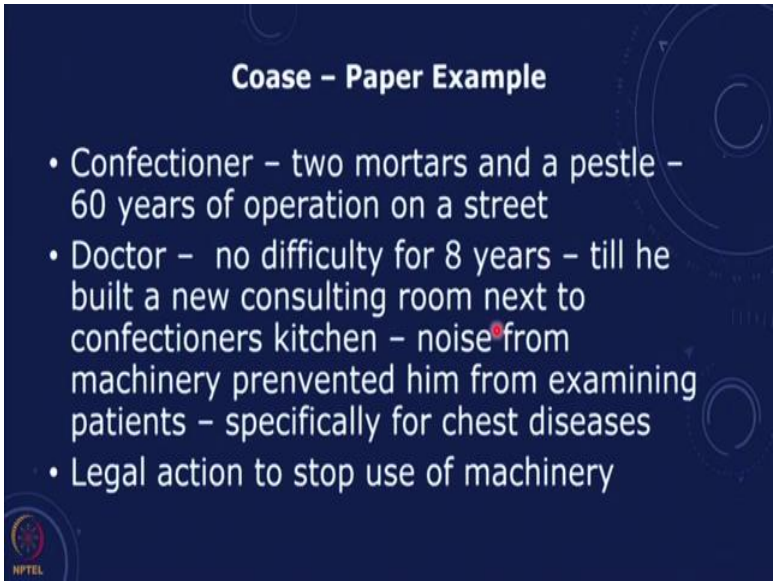

So, the example that he gave Ronald Coase talked of in his paper is that the confectioner is making cakes and other confectionery items and this has two mortars and a pestle and have 60 years of operation on a particular street. So, it has confectionery shop which was doing fairly well and it is been there for a long time and there was also a doctor's clinic at the same time and there was no difficulty for the initial eight years and till the doctor built a new consulting room next to the confectioner's kitchen.

And the confectioner, the noise from some of the confectioner's machinery prevented the doctor from examining patients, specially for chest diseases where the sound being used from the chest which has to be actually assessed by the doctor, the sound of the machinery affects that and there was a case which was filed and legal action to stop the use of machinery. And so, the court ruled in favor of the doctor and got an injunction against the use of machinery.

And what Coase says is whether the doctor won the case or the confectioner won the case, the final result would be the same and bargaining is possible. The confectioner could assess what is the doctor's loss of income, and because of that, the doctor could move, so depending on what is the amount of loss of income caused by the doctor or the doctor's inconvenience to move to another location could be the cost which is incurred. And if the confectioner's revenue exceeds that, the confectioner could compensate the doctor for this.

And this would be done even if the confectioner… The doctor could build a wall or mitigate the noise and this could be done where the confectioner, if the doctor had the rights and the confectioner is losing out on, the doctor had the right and the doctor stops the confectioner

from continuing its operation, the confectioner's revenue exceeds the losses of the doctor, the confectioner could then pay the doctor to build a wall or to mitigate the noise or to move.

And if the confectioner had the rights, and the doctor had a loss of income and that income was less than the confectioner's the doctor would go ahead and build the wall to mitigate the noise.

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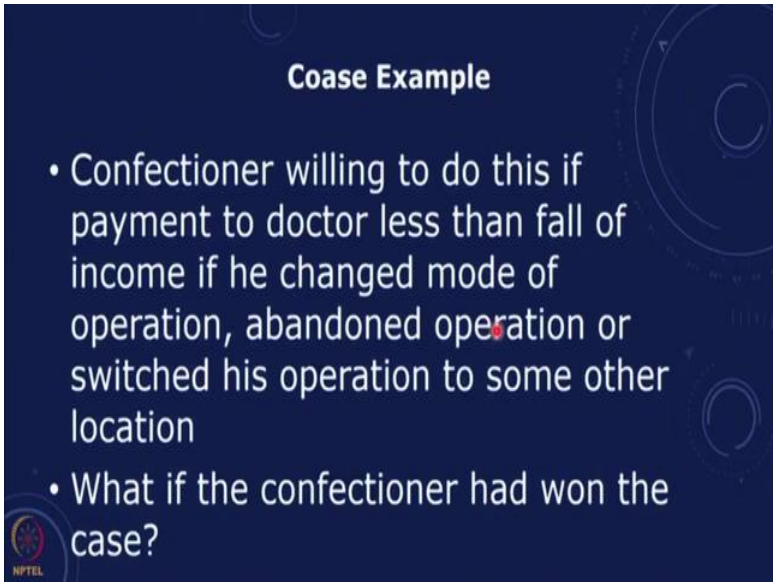

So, the interesting thing, so the thing is that confectioner willing to do this if the payment to doctor is less than the fall of income if he changed the mode of operation, abandoned operation or switched his operation. So, what if the confectionery had won the case? If that is confectioner has won the case, then it would depend on the doctor making the, getting the loss of revenue, and the doctor would pay the confectioner to continue the operations or make its own.

So then basically, if there is no, if this transaction cost is negligible, or is zero, then it does not matter who has the rights and this is the, this is a very interesting kind of statement. Of course, in practice we always have transaction costs and in terms of fairness, there is always the issue of compensating the, in the case of an industry you have to compensate the people who are affected, and so externalities and of course in all of this, there is an issue of tradeoffs and costs.

And there is an issue in terms of the equity and fairness. So, with this, we complete the portion on analysis of externalities and we will move on now and we will talk in terms of financing of energy.