**Introduction to Environmental Economics**
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Lecture – 47
Pigouvian Fees

Hello everyone, we are continuing from the earlier lecture. So, we are discussing how to internalize the externalities. In this context we have already discussed, what is the Coase theorem and how we can internalize the externalities by Coase theorem itself. So, today we will be discussing another mechanisms to internalize the externalities that is the Pigouvian Fees or which is also known as the Pigouvian Taxes.

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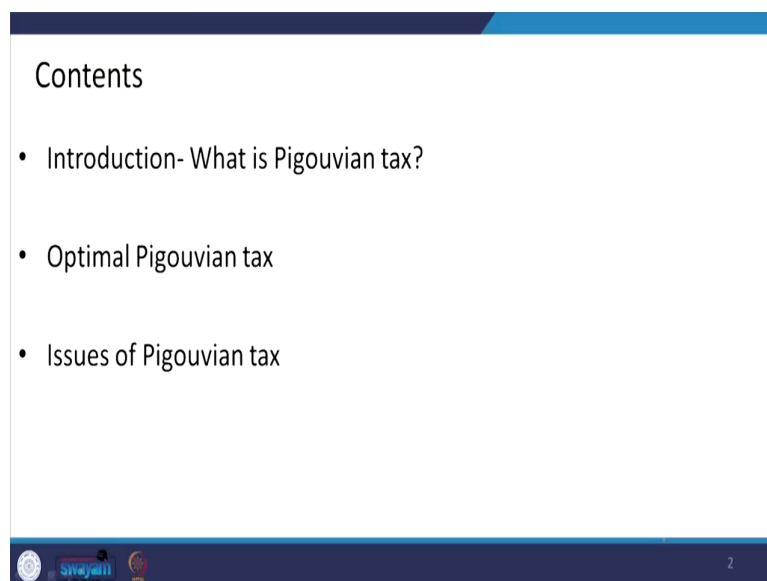
So, in this lecture we are planned to we have plan to discuss what is the Pigouvian tax itself and we will be discussing what is the optimal Pigouvian tax and then we will be discussing

what are the mechanisms of Pigouvian tax. And finally, we will be discussing: what are the different issues we are facing in the concept of Pigouvian tax itself.

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So, let us start with the introduction part that is our question is, how to internalize the externalities; that means, how to intervene if there is any case of externalities, so that we need to reach the social optimum. So, in this context when our target is to reach the social optimum and there is the presence of externalities, what would be the intervention mechanism so that we can achieve this social optimum, that is the questions.

And, as we understand that we have already discussed the case of Coase theorem. So, what is Coase theorem about? It talked about the bargaining power that is the private bargaining and negotiations they can help in internalizing the externalities. But, if this private bargaining and

negotiations they fail then and the marginal taxes and subsidies are the mechanisms, that can help the firms to internalize the externalities.

So, the thing that we need to highlight here is that when the Coase theorem is not going to be applicable or when the bargaining and negotiations they fail in internalizing the externalities in that case this marginal taxes and subsidies they are used as direct mechanisms to internalize the externalities. And, in this case we are introducing a concept a tax concept which is known as Pigouvian tax.

So what is this Pigouvian tax? This is a tax that are imposed on the polluter itself who are causing the damages and this tax is imposed based on the estimated damages or estimated external cost. And, when this tax is equivalent to the estimated damage or estimated external costs such tax is known as the Pigouvian tax itself.

So, this concept of Pigouvian tax it is it has been introduced by Arthur C Pigou in his book 'Economics of Welfare'. So, the first addition of the book it was published in 1920 and he proposed that a tax can be a mechanism or it can be an instrument which can help us equating the private cost with the social cost. So, in the pollution or externality problem the biggest challenge is that, this private cost is not equivalent to is not equivalent to these a social cost and that is why there is the problem.

And, here in economics welfare who is Pigou published in 1920 he proposed a theory that is in terms of taxation. So, there he can use this tax as an instrument and this tax can be used for equating this private cost with the social costs. So, how it can be equalized? The private cost is equalized or equivalent with the social cost and we know that in case of externalities private cost is not equal to the social cost right.
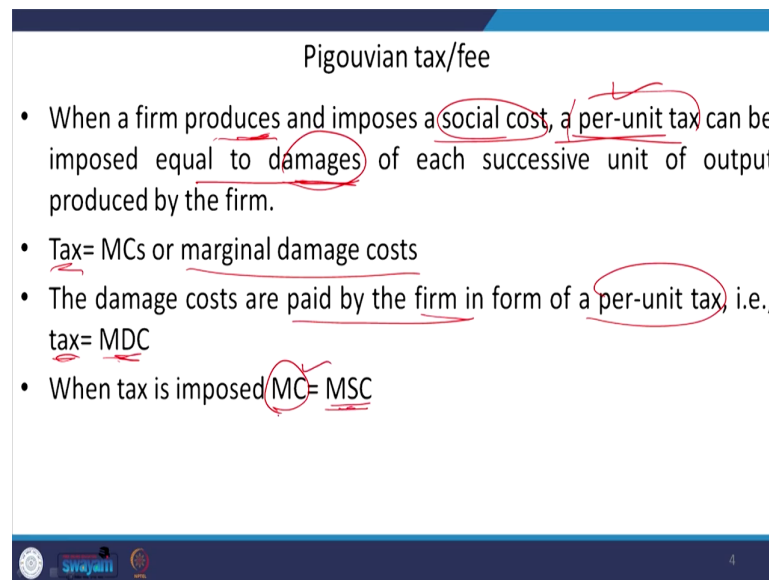
So, that means, if the private cost in addition to the externalities that is equivalent to the social cost. So, what Pigou proposed that, if the private cost is added with the taxes or the polluter or imposed with a taxes for the externalities or damage done because of externalities now it

will be equivalent to the social cost itself. So, after understanding this the very basics of Pigouvian tax that what is the concept itself.

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Now, we can say that here in as per the Pigouvian tax or sometimes we are saying Pigouvian fees itself the, when a firm produces right the output and hence produces the any kind of externalities let say pollutions. So, it will be imposing a social cost, pollution is a social cost here right and as per this Pigou suggestions Pigouvian tax a per unit tax can be imposed right. And, this per unit tax should be equivalent to the damages from each successive units of output produced by the firm itself.

So, here we are saying that what would be the amount of tax, that the amount of tax would be the would be equivalent to the damages that are generated from each successive output produced. So, here we are saying that this tax is determined on the basis of the marginal

damage cost that is a per unit tax or the damages for that is generated from each successive units of output right.

So, the here the damage costs are paid by the firm in form of per unit tax. So, that is why you are saying this tax is equivalent to or tax is in terms of the marginal damage cost and when this tax is imposed that is the marginal damage cost is imposed right. So, it will be equivalent to your marginal social cost. So, that is why you can say your this marginal cost is equivalent to the marginal social cost when the tax is imposed.

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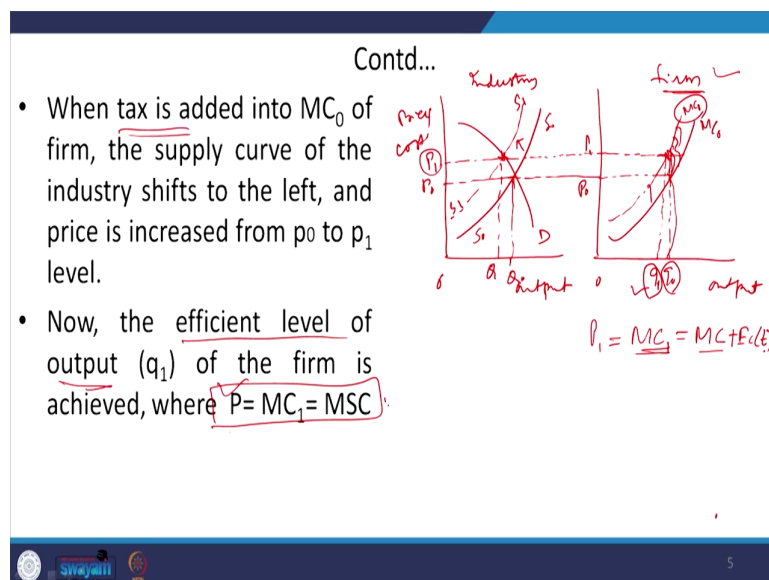
So, in this context we can just need to highlight that let us say we just remember that how a particular firm is generating its productions and the how in the perfectly competitive market how the firm is a price taker. So, now, we will be talking about the case of industry and the

production and the case of a particular firm which is producing a product and simultaneously it is also producing the externalities or pollution itself right.

So, initially as you understand it is the output axis and here we represent the price or cost and accordingly how the price and output is determined, it is depending upon the demand side and supply side functions right. So, this is the initial level of supply and this is the demand for the output. So, as a result we are saying the intersection point we are finding the optimal level of output and the equilibrium level of price for that output itself.

So, based on these the firm is also a follower he is just a price taker or he cannot be a price maker. So, he follows the firm follows the same prize level p 0 right and how the firms output is determined, depends upon the marginal cost itself. So, this is the marginal cost of the firm itself. So, when the price line is intersecting marginal cost. So, this will be the q 0 output, it is the equilibrium level of output ok.

So, now based on this understanding now we are saying that a tax is added because the firm is polluting right or it is generating some externalities. So, its private cost it is not equivalent to the social cost. So, that is why in order to make the marginal cost equivalent to the social cost a tax is added here right in this marginal cost curve. So, the because the tax is added, let us say this amount of tax is added. So, because this tax is added the supply curve of the industry it will be shifting leftward. So, let us say the supply is shifted supply curve will be shifting to the leftward.

So, now the new supply curve will be s 1 s 1. So, now we will be having a new equilibrium point so, by this is the new price level and this is be the new output level right. So, now, as we understand the firm cannot be a price taker so, it just follows the price whatever is determined by the industry itself. So, at the intersection point this is the marginal cost curve right and this point where the price and marginal cost curve new price and the marginal cost curve is intersecting.

So, this point is known as the q 1. So, now, the q 1 level of output is produced. So, as a result when the tax is imposed this is the tax amount this is the tax amount, when the tax is imposed

in the on the firm. So, what will happen, the price is increased from p 0 level to p 1 level and now the efficient level of output for the firm will not be the q 0 rather it is the q 1.

So, why we are saying that q 1 is the efficient level of output for the firm itself, because at this level of output the price that is p 1 is equivalent to the marginal MC 1. So, what is MC 1, the marginal private cost plus the external cost that is in terms of tax right. So, this is the marginal external cost plus the external cost. So, now, it is the marginal external cost this is the new one right.

So, as a result what we are saying that this q 1 level of output this is considered to be the efficient level of output because this conditions is achieved that is price is the total cost is internalized in terms of the price and the price is equivalent to the new marginal cost which is reflecting the external cost as well. So, now you can say the price is equivalent to the new marginal cost that is equivalent to the marginal social cost right.
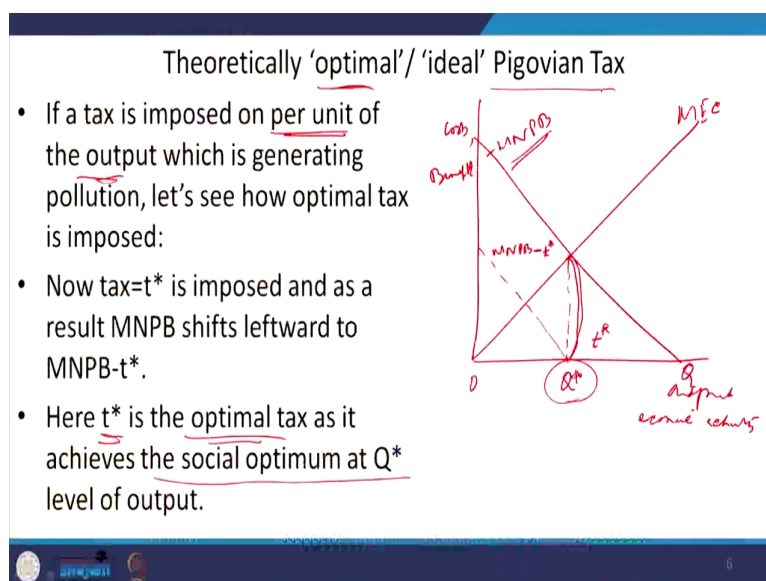
So, now we can theoretically understand: what is the ideal Pigouvian tax which is also known as the optimal Pigouvian tax. So, now you can now you can remember the Coase bargaining theorem and optimal externalities in this context we discussed the optimal externalities. So, there we talked about this is the output or economic activity these are the costs or benefits we are measuring the vertical axis and how the optimal level of externalities is decided by taking into account the marginal external cost and marginal net private benefit.

This is your marginal net private benefit we have already derived. So, this is the optimal level of economic output, this is the q level. So, now, how to determine that which one is the theoretical optimal or ideal level of Pigouvian tax. So, now, as you understand in the Pigouvian tax a tax is imposed and what is the basis of imposing this term this tax that, this tax is imposed on per unit of the output right.

So, when you are saying per tax is imposed per unit of output so, now, we say that this tax is t star, because and this is the optimal level of pollutions right and optimal level of output. So, if per unit of output tax is imposed. So, the tax will be the tax amount would be this much. So, now, the let say this much of tax is t star which is imposed and when this t star tax is imposed; obviously, what will happen, this marginal net private benefit it will be shifting leftward ok.
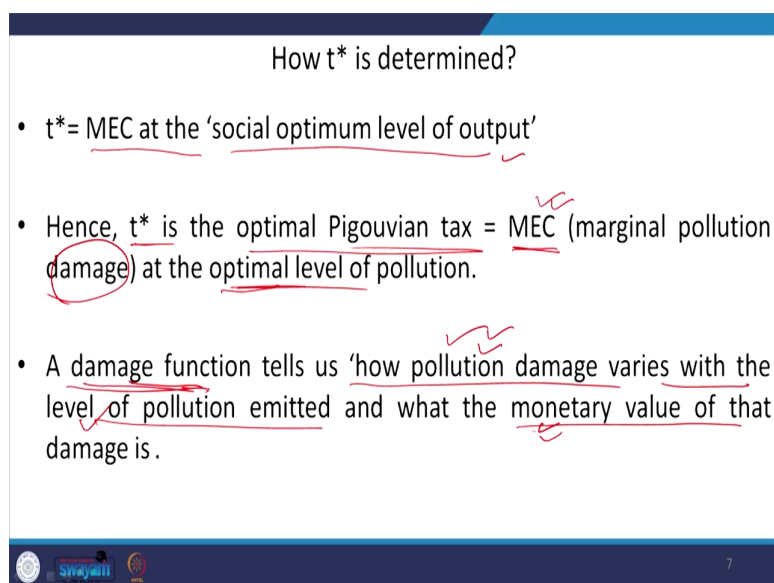
So, now, what will be the shape of this marginal net private benefit curve? So, this will be the new marginal net private benefit which is known as marginal net original marginal net private benefit minus the tax is imposed that is t star. So, here when t star is imposed, t star is the optimal tax right and why we are saying t star is the optimal tax, because it is achieving the social optimum social optimal level of output and pollutions right at Q star level of output right.

So, this is how we learnt that from the optimal level of output how you are finding the optimal level of Pigouvian tax or what would be the tax and that is imposed which is known as optimal level of tax. So, now, the next question is how this optimal level of tax t star is determined?

So, here we are saying that t star is determined or t star is defined at the marginal external cost at this point which point, this is the social optimum level of output that is the q star level of output. So, t star is the optimal Pigouvian tax which is equivalent to the marginal external cost or here we are talking about the marginal pollution damage, at this point at this particular point which is the optimal level of pollutions right. So, in this case we are saying that when marginal external cost is there what is the cost, cost is in terms of the pollution damage.

So, what is this pollution damage? So, this is a damage functions right this can be understood by a damage function and this damage function tells us two things. One is how pollution damage varies with the level of pollution emitted this is the first thing, the pollution damage can be varies with the extent or level of pollution emitted and the second one is the how the

pollution damage it can be varied depending upon the monetary value of that damage right. So, these two things are explained in this damage function.

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Mathematical representation of Optimal Pigouvian tax
- We know that,
- NSB= gross benefits of polluting activity (P.Q)- pvt. Cost (C) – external costs (EC)

- NSB= PQ- C(Q)- EC (Q)   (1)
- Where, P= price ; Q= output

So, now let us understand this same optimal Pigouvian tax by mathematical representations, now we can say that we already know this net social benefit, how you are defining. This net social benefit is the gross benefits of the polluting activity right so; that means, in terms of production itself.

So, gross benefits that the firm is getting from producing and also generating this activity and the private cost what is the cost, the firm is incurring in order to produce the outputs and for this production what are the external cost that are not included in the private cost itself right.

So, what we are saying that this net social benefit is nothing, but the Q; that means, the quantity of output produce times the price in the market price per unit of this output. So, this is P Q, this is the gross benefit of polluting activity in terms of producing the output minus the private costs. So, when this quantity of output is an increased then; obviously, the cost private cost will be increasing.

So, that is why c j function of your output so, likewise minus the external cost. So, again when the output is increasing the pollution is also increasing. So, that is why your external cost will be increasing. So, external cost is also a function of your Q. So, and here this P equal to price and Q is equal to your output.

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So, based on this net social benefit understanding now, what you need to do, we need to maximize this net social benefit. So, how to maximize this any functions then; obviously, we

will be saying that we can maximize any function by taking the first order derivative to the 0. So, here the first order derivative with respect to the output is equivalent to this is already defined already in the equation 1 PQ minus C of Q minus EC of Q right which you are saying let say it is equation 2 so, d by d Q.

So, now after getting this how what you are getting P minus d del of Q by d Q del minus del of this is P this is del of Q del of C by del Q and this is del of EC by del Q equal to 0 this is the first order condition to be 0 this is nothing. So, now, you are saying that P minus del of C by del Q minus del of EC by del Q equal to 0 so; that means, you are saying P equal to delta C by del Q plus right del EC by del Q this is equation 3. What is this, del C by del Q this is nothing, but your private cost what is del EC by del Q. So, this is nothing, but your marginal external cost ok.

So; that means, you are saying this price is nothing, but the combinations of private cost marginal private cost and marginal external cost right. So, that we were saying P equal to this is nothing, but your social cost marginal social cost. And, from this equations that is we are saying from let us say from equation this is 3 right we are saying P minus del C by del Q is P minus del C by del Q is nothing, but your del EC by del Q let say it is 4 ok. This is price minus the marginal cost, what is the price it is the benefit to the private firm.

So, that you can say the private benefit minus the private cost this is equivalent this is nothing, but your marginal net private benefit equal to what is del EC by del Q, this is the marginal external cost right. So, now you are saying this marginal net private benefit is equivalent to marginal external cost at this point when marginal net private benefit will be equivalent to marginal external cost at that point you would be saying we are having the optimal externalities ok.

So, there you are saying we achieve these optimality conditions, which we are saying that del of net private benefit with respect to the quantity of output is nothing, but del of by del Q. So, this is equation. So, when you are introducing a tax that is equivalent to the tax must be decided on the basis of the social optimality right. So, now, you are saying that let the t star is

equivalent to del of your external cost right. So, now, you can follow this equation that is P equal to this is the equation 3.

So, what we are doing, P equal to from equation 3 itself if you are putting the value of t then del c by del q plus t star itself right. So, now you are saying this tax is imposed and because of this imposed region of tax your this externalities is internalized and now the price is reflecting or including the external cost as well.

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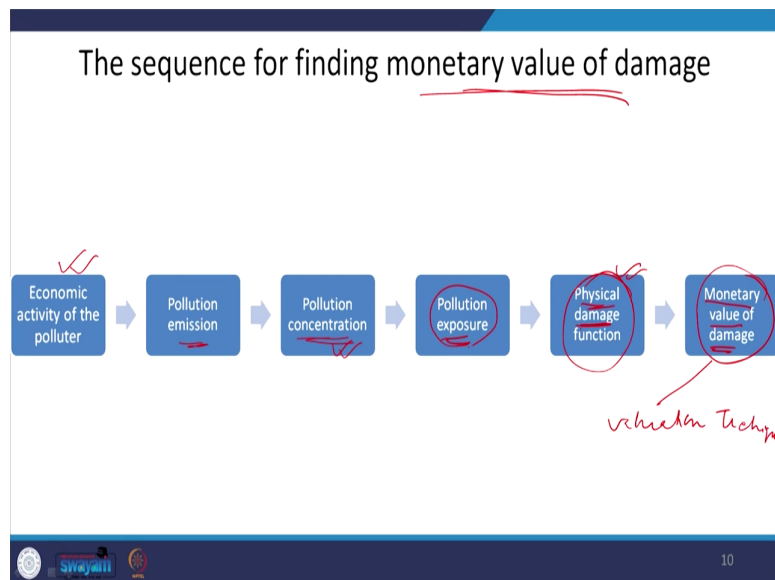
We can say that, what is the sequence for finding this monetary value of damage, because that is the point, that we need to need to understand in order to have this optimal level of tax. So, for finding this monetary value of damage what do we need to find, the first of all we need to identify what is the economic activity or what kind of production the firm is producing and because of which the byproduct is the pollution itself.

So, this is identifying the economic activity of the pollute of firm itself. Then next level after identifying we need to see need to identify and estimate what is the pollution emission to what extent. And after finding this pollution emission next one that needs to be clarified is the concentration of the pollution, whether it the pollution is generated and diffused or whether it is it gets concentrated over a particular geographical area or special area.

So, again this concentration is going to effect the exposure. So, if the concentration is high then; obviously, the exposure will be high. So, this pollution it is leading to the pollution exposure. And, this when the pollution exposure is high then; obviously, it will be leading to the physical damage of the goods and services all even the health itself.

And then we are identifying from the physical damage function we are identifying the monetary value of damage itself, as you understand in the physical damage function we have included both the both the what is the extent and what is the exposure level. So, this is how we are calculating the monetary value of damage, how you are calculating the monetary value of the damage that we have already understood from the valuation non market valuation techniques right, rebuild and stated preference methods.

For understanding this emission damage sequence that we talked about we need to understand two concept, the first one is marginal external cost concept or what are the components of marginal external cost and what are the components of marginal net private benefit right.

And, as we understand in case of the firms we have we are facing this problem that is the commercial confidentiality of information, because of this problem because of this issue the we can actually get adequate information or the information related to the composition of this MEC right, marginal external cost and marginal net private benefit.

So, because this is there is a problem of getting the information about the MEC and marginal net private benefit. Therefore, it is sometimes argued that when the government or any government agency it is acting as a regulator let say for regulating the pollution itself.

So, this they may not be in a very strong position to extract the related information on the MEC and marginal net private benefit. And because now we understood that there is a there is an asymmetry of information itself, because the polluter is having the information whereas, the regulator is not getting adequate information from the polluter itself.

So, this is because of which it is leading to the objects on if the government is acting as a regulator or government is proposing any kind of intervention in order to internalize the externalities. So, before going to address the issues of Pigouvian tax we can now address the case of this optimal Pigouvian tax right, we are saying that how to mathematically represent the optimal Pigouvian tax. So, as you understand that marginal this net social benefit is the this P Q minus C Q and E Q right. So, how to find the optimal? Then obviously, we need to maximize.

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So, based on this understanding now we can find out we have what we have discussed we have discussed how to find out the Pigouvian optimal level of Pigouvian tax theoretically and also by mathematical representations. Now we can find out what are the issues of Pigouvian tax, what kind of issues and limitations we are facing in Pigouvian tax itself.

So, broadly we will be having we will be now discussing two types of issues, the first one is the Pigouvian tax in terms of the property rights when property rights are defined or in presence of property right, how this Pigouvian tax is function right. So, now, we can draw this that how this Pigouvian tax is going to function in case of the property rights ok.

So, this is as usual we are trying to find out the optimal level of so, this is your output and this is your cost and benefits ok, this is your marginal external cost and this is your marginal net private benefit. Let us say this is 0 this optimal level is known as the Q star level that is optimal level of output this is let say Q pi or Q max right. And, this intersection point where marginal net private benefit is intersecting with marginal external cost is equivalent leading to the optimal level of output and pollution. So, this is known as b e and this is C right.

Now, we will be looking to that this is the optimum optimal level of output to be produced. So, if, but initially if you are assuming that the polluter has the property right then; obviously, the polluting firm will prefer to produce at this point that is Q Q pi or Q max point. So when the firm or the polluting agencies polluting at Q max or Q pi point then the total pollution tax right would be how much because the firm is producing at this point and simultaneously we are saying that when it is producing it is also producing not only the output, but also the externality or pollution itself.

So, as a result what the polluter will be doing, the polluter is a imposed with a tax or a tax bill. So, how much of the tax bill is imposed. So, for if the producer is producing at this 2 max point then the total tax bill that is paid by that is to be paid by the firm itself. It is the total area ObdQ star this area plus Q star deQ pi area right. But if you see if you will be looking closer than you will be finding that this much of tax bill right this much of the tax bill it is not feasible

to be paid on the part of the firm or the polluting agency why, because this tax bill that is Q star deQ pi is more than the net private benefit.

What is the net private benefit? Net private benefit curve is this much so; that means, if the producer is producing OQ pi or OQ max level of output it is having the benefit of this right. However it has to pay the tax of this so; that means, it is simply not feasible on the part of the producer to pay the tax bill of this amount. So, as a result what will happen in order to avoid this tax the producer will be decreasing it is output from Q max level to Q star level and this is the theoretical thing that we are also anticipating. So, the pollution or output now will be reduced to Q star level.

Even after reaching the Q star level the polluter is still paying this amount of tax bill ObdQ pi and even though we are saying the firm is producing and the optimal level of pollution and the optimal level of output, but still it has to pay this much of this much of tax bill. So, if you observe this case then would be finding that it seems the polluter is penalised twice, how the polluter is penalised twice? The first it is forced to cut back it is production from Q pi or Q max level of output to Q star level of output right and the second one even though the polluter is producing at the optimal level of pollution and output Q star it has to pay a tax bill of ObdQ star right.

So, which in this context we are saying it is a issue; it is an issue which is related to the fairness right. And some of the other challenges or issues that we are talking about is that for identifying and estimating this proper Pigouvian fee we need to find the monetary value of the damage at the optimal level of output. And, we have already shown that what is the stages or what are the process for which we need to we can calculate the monetary level of damage itself.

And, if at all this monetary value of damage and it is state is estimated and the Pigouvian fee is introduced generally this Pigouvian fee are leveled levied it is imposed on the emissions or the ambient concentrations. And, both this emissions and ambient concentration it is measured in terms of physical units not the damaged units. So, that means, we cannot actually assume emissions and concentrations they are related in one - to - one fashion right.

So, they may be there may be difference between these emissions and concentrations in the in the context of geographical locations. So, in this context what we need to take into account in order to set this proper Pigouvian fee is to consider the assimilative capacity of the nature, because emissions may be different and the constitution make be different depending upon the assimilative capacity of the nature right.

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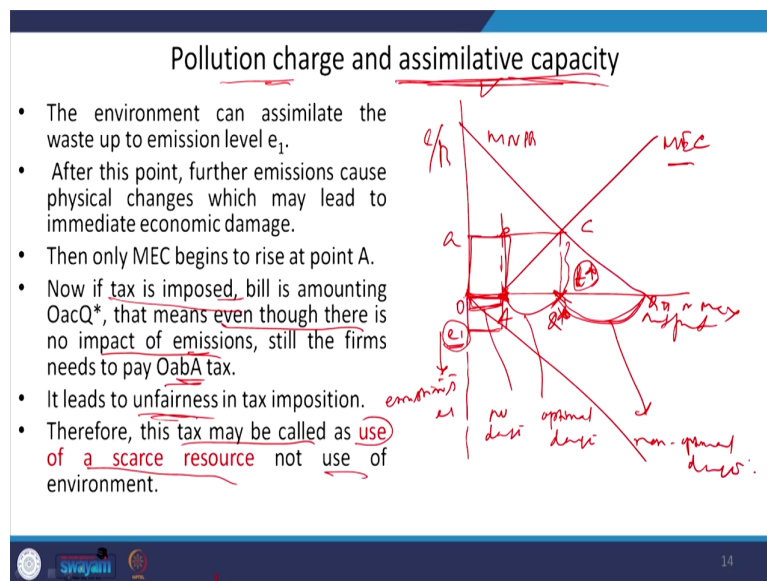
So, now let us look at what is the assimilative capacity of nature and how this Pigouvian fee can be charged in the presence of assimilative capacity of nature. So, now, what we are saying that even though the pollution is there, there is the natures capacity to assimilate some portion of this waste naturally the waste can be assimilated right. So; that means, it is physical effect is not effective or it is not going to affect any kind of harm it is not going to affect negatively.

So, that is what is defined as the assimilative capacity of the nature which is the natures own capacity to assimilate and correct the waste ok. So, we can actually do this in the presence of these we are saying this is the output level and this is your costs and benefits and this is as usual this is the marginal net private benefit curve. What we are assuming earlier is that the marginal external cost it was starting from 0 origin; that means, we are assuming that when the output is generated output is produced then automatically the externality is produced right.

But, now as you are assuming that the assimilative we are take into account the assimilative capacity of the nature. So, that is why and there is some extend this externalities can be corrected by the nature itself which is known as the externality assimilative capacity that is why the marginal external marginal external cost it will not be starting from 0 origin, but from here right. So, this is the level where if at all any externality is produced, it will be corrected by the natures itself nature itself by it is assimilative capacity it is not going to harm or damage anything.

So, now the shape of this marginal externality curve this is this is the Q star this is the Q pi or Q max you are saying and this is let say this is assimilative capacity is denoted by a this is b this is c and we are also displaying below this 0 axis we are also displaying the emissions level this is e 1 and let say this is e 1 of emissions you are we are representing the emission itself. And, here the we are assuming that the environment itself it can assimilate the waste right up to the emission level e 1; that means, if the emission level is e 1 then the nature can assimilate it itself.
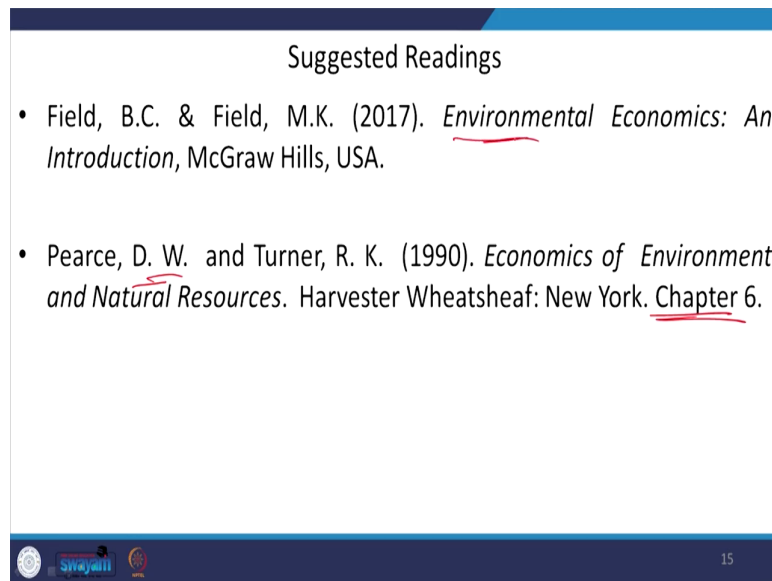
So, after this point of this A if further emissions are created generated then; obviously, it is going to affect the physical change and as a result the economic damage can happen. So, now, we do understand that this marginal external cost is is drawn and now what you are saying that in presence of the assimilative capacity how this Pigouvian tax is going to function right. So, now, you are saying the tax is imposed, what is the tax is imposed, which tax? This is the tax let us say t star amount of tax is imposed why we are saying t star is imposed here because the Pigouvian fees is always fix is charged on the optimal level of output.

So, that this is the optimal level of output so that is why this at this point the t star is is imposed. So, as a result the what is the tax bill, the tax bill would be the OacQ star amount. So, this is the tax bill that a firm needs to pay right. And even though there is no impact on the emissions because still Oa level even though there is emissions, but there is no impact, but still the firm needs to pay this Oab sorry Oab and capital A amount of tax.

So, what you are concluding that, even though this is not this level of pollution is not producing any kind of damage, but still the firm is need to firm needs to pay this tax so, it leads to unfairness in tax imposition itself. And therefore, this tax may be called as the use of scarce resources not use of the environment itself right. So, we what we are saying that at this level of output Oa level of output and pollution there is no damage and from A to Q Q star level of output and pollution so, it is you are saying that this is optimal damage.

And beyond this Q star to if the production is happening from in between this point Q star to Q pi or Q max it is known as the non-optimal damage.

These are the suggested readings for this for this Pigouvian tax or Pigouvian fees you must go through chapter 6 of this book and you can also refer to this book environmental economics an introductions.

Thank you very much.