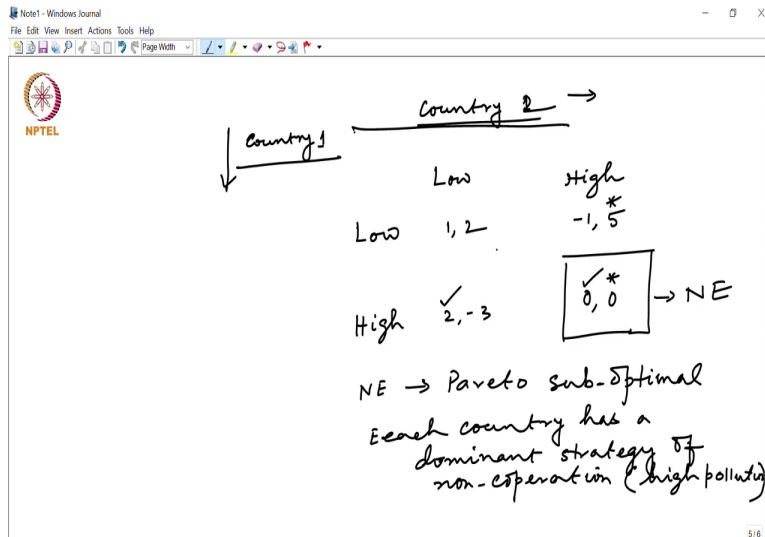**Environmental and Resource Economics**
Professor. Sabuj Kumar Mandal
Department of Humanities and Social Sciences
Indian Institute of Technology, Madras
Effectiveness of Incentive design and Economic valuation of Environmental goods
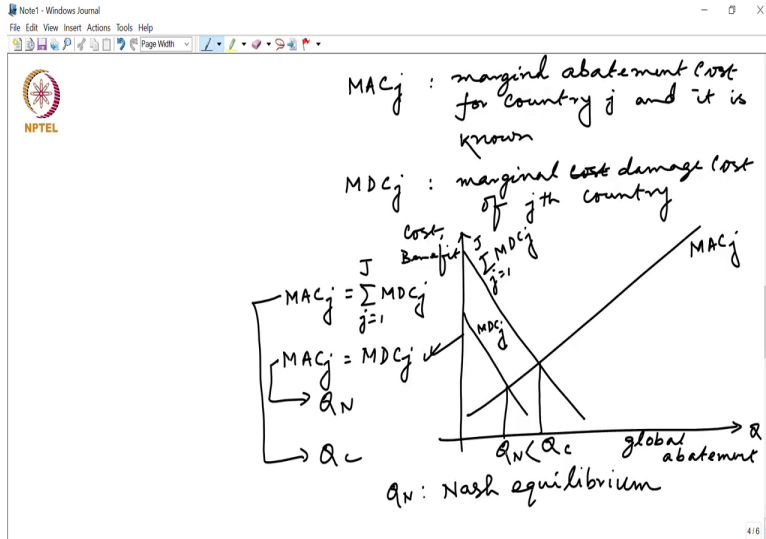**and service Part – 6**

Now, what we can do, we can analyze this situation by constructing a simple payoff matrix which we learned in our basic microeconomics and principles of economics. Let us, analyze this case let us say that there are only two countries in the world and each country has two strategies either to go for cooperation that means, pollution reduction which will lead to lower level of pollution or non-cooperation which will lead to high pollution.

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So, let us say that this is low pollution for player 1 or country 1, this is for country 1, what are the strategies? Low pollution and high pollution. Similarly, for country, this is country 2 and we will put country 1 left side. So, they are also low and high and the payoffs are like this 1,2, minus 1, 5, 2, minus 3 and 0, 0, this is for country 2 and this is for country 1.

So, countries 1 is this side, country 2 is that side. Now, out of this pay off metrics let us try to find out the equilibrium or solution, let us assume that country 2 decides to cooperate that means to emit only lower level of pollution, then what is better for country? If country 1 goes for cooperation it gives 1, it gets 1 by non-cooperation that means generating high level of pollution it gets 2.

So, obviously when country 2 goes for low that means cooperation, non-cooperation or high level of pollution is better for country 1. Similarly, when country 2 goes for non-cooperation generates high level of pollution, if the country 1 generates low then it will get minus 1, if the country goes for a high level of pollution it is get 0, since 0 is good at the minus 1, country 1 will go for high level of pollution.

So, that means one thing is clear, irrespective of whatever for country 2 does, non-cooperation or generating high amount of pollution is better for country 1 that is why we say that a high

pollution or non-cooperation is a dominant strategy for country 1, what we say non-cooperation is a dominant strategy for country 1.

Similarly, if we think from country 2 point of view, if country 1 goes for low level of pollution, then country 2 should go for high level of pollution, because 5 is greater than 2, when country 1 goes for high level of pollution, country 2 should go for high level pollution, because 0 is greater than minus 3, that means country 2 also has a dominant strategy.

So, that means we can see that when country 1 goes for low level of pollution, country 2 should go for high, so high is better for country 2, because 5 is greater than 2, we are denoting the best strategy by a star mark. Similarly, when country 1 goes for high level of pollution, country 2 should go for high level of pollution, because 0 is greater than minus 3.

Now, the cell consisting of best strategies, best responses of country 1 and 2 is actually the equilibrium, this is called Nash equilibrium in the literature of game theory. Now, this particular equilibrium has an interesting feature, what is this? That means the solution of this game source even though cooperation is better for both the countries, cooperative solution is 1 2, which is greater than 00 see, at cooperation both the countries are better off, at non-competition leads to Pareto suboptimal situation.

So, this Nash equilibrium is actually Pareto suboptimal, why this is suboptimal in terms of the diagram also we can understand that when they are not cooperating that is leading to lower level of global abutment more pollution, which is bad for all the countries, but still they are not able to reach at the cooperation, why? Because each country has a dominant strategy in non-cooperation, each country has a dominant strategy of non-cooperation that means a high pollution.

Because of this existence of a dominant strategy in terms of non-cooperation countries are not able to arrive at cooperation. And that is basically the classic problem of not getting a solution for a global climate change or global warming problem. So, with this simple model, this model of two countries can easily be extended to N country game and with that extension we can easily

understand why this is so problematic, so difficult to control, global pollution, which is a free riding problem.

Each country has a tendency to deviate from the corporation because that deviation gives better outcomes. So, when all the countries are thinking in the same line of non-cooperation, non-cooperation and non-cooperation is becoming the solution of the game, which is leading to more pollution which is bad for the country. Then, how to solve this free riding problem? So, what is the solution?

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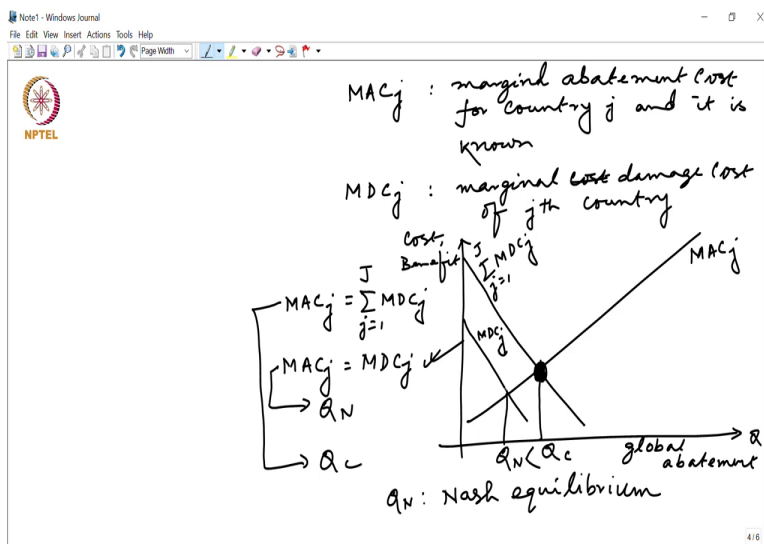
See, when the countries are deciding to cooperate that means at this level at this level, when the countries are deciding about this level, this is for cooperating solution. Now, we should understand one thing that different countries are at their different level of development, for example, India is at a particular stage of its development, China is at a particular stage of its development, UK, US, France, Canada, all these countries they are in a particular level of their development.

Now, at this stage, if the country decides to go for global agreement and to reduce the pollution, let us say all the country decides to reduce the pollution by 2 percentage, then this cooperating solution becomes problematic for some of the countries, some of the countries may worse off, if the goal for cooperation, Why? Because the poorer countries they have just started their growth process, developmental process, which requires production of more goods and services.

So, at this stage, if they are also bound to reduce their pollution, that means they need to reduce their production activities which will hamper their growth and development, developed nations, they have already achieved. So much of development in their country, so they can afford to go for such cooperation and then they can reduce the pollution, while others who have not traveled so much in the in the developmental paths, it becomes really problematic for those countries to come for such cooperation.

So, that means we need to design a side payment economists they say that we need to design a side payment, since some countries are worse off at the cooperation, then what do we need to do, if we see that the global benefit cooperation is higher much higher than the loss of some specific countries, then the countries who are getting benefit out of this cooperation they should actually compensate the loss of these countries.

If the losses of these countries are compensated by a side payment, then only there is a chance that these countries will always will also go forward such cooperation, cooperating activities to reduce pollution globally, and such a side payment can actually solve the problem of free riding. Without such side payment it is very difficult to achieve cooperation to achieve international agreement for pollution reduction.

But the question is then, how will you design the side payment, what type of side payment, how will you distribute the side payment, whether that will actually be paid or not. So, that means this side payment mechanisms should be credible one, so it should be credible side payment. So, that means all the countries should be convinced that this is the way other countries are going to compensate the poorer countries, then only they will cooperate and we can solve the problem of transboundary pollution or international externalities.

Unfortunately, even though theoretically it sounds good, countries could not achieve such type of side payment even now, that is why even in the twenty first century also we see the threat of global warming, because they have not yet come up with some credible side payment mechanism that can actually convince all the countries to cooperate that can convince all the countries to avoid such free riding.

So, countries should put more effort to this mechanism of side payment, if the global benefit is higher than the loss of some of the countries. So, with this, this is basically the summary of transboundary pollution, so what we discuss basically in short that certain type of pollution are transboundary nature, because pollution does not respect the political boundary, and classic example of such transboundary pollution are international externalities, acid rain, global warming, these are all examples of transboundary pollution.

No supranational government exists to impose any type of market this instrument on a specific country where the pollution is getting generated, that is why the mechanisms we discussed earlier in the context of national externality is not at all applicable in the context of transboundary pollution or international externalities. It requires cooperation or international agreement, all the countries should take responsibility to reduce the pollution.

However, even though all nations they have a common interest to reduce their pollution. At the private level, no country has an incentive to reduce the pollution at their own cost. Because global climate global environment is like a global public good, irrespective of whether a country cooperates or no country can be denied or no country can be prevented to enjoy the benefit from the abatement activities taken by others.

So, we have analyzed the situation in terms of the game theory a simple model. So, ideally each country should equate the marginal cost of abatement with the global marginal damage cost. So, that is the global benefit. So, each country equates their cost with the global benefit, then we will arrive at the situation, QC higher level of abatement. However, since each country has an incentive to deviate, each country has an incentive to non-cooperation, it will lead to QN level of abatement that means country will equate MACj with MDCj only, jth country is bothered only its own cost on benefit.

In terms of this simple pay off matrix even though low level of pollution that means cooperation is beneficial for country 1 and 2, because of the existence of a dominant strategy of non-cooperation it leads to a situation wherein the countries are getting on the parrot or suboptimal benefits. So, sub optimal benefits, that means it is difficult to achieve cooperation, even though it is beneficial for both of them.

Then economists they could think of a side payment, wherein the countries who get benefit out of this global competition they must compensate other countries who are getting loss out of it, who are worse off, if the global benefit is higher than the loss of some specific countries, but such side payments would be credibly designed, it must be credible enough to convince all the countries particularly the poorer countries developing and underdeveloped countries that yes, if we also take part in this global cooperation, then there are countries who will compensate us, for such activities. So, that is the solution for controlling global climate change controlling transport, with this, we are closing our discussion today. Thank you.