Environmental and Resource Economics
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Effectiveness if Incentive design and Economic valuation of Environmental goods and service Part: 4

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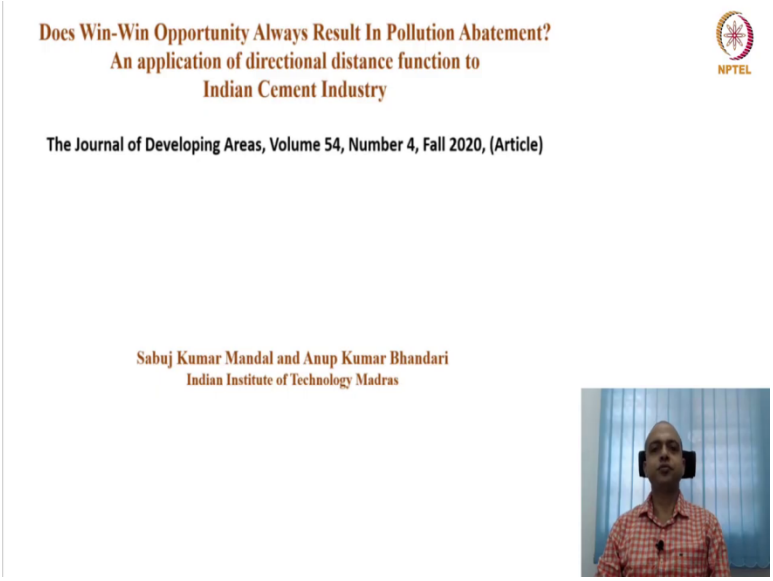

Welcome to our discussion on environmental economics and in our last couple of sessions, we were discussing different types of market based instruments for pollution control, we have discussed the effectiveness of such instruments under different conditions. And we have also discussed about Porters hypothesis in this context. Wherein, he said that regulation as it is perceived by the traditional wisdom is not always bad.

Rather, a properly designed and implemented regulation can motivate the forms for innovation and that leads to a win-win situation wherein, the forms produce lower amount of pollution at the same time, higher amount of output. We have also discussed the counter argument or portal hypothesis, but because of its importance in form performance and competitiveness, a large number of empirical studies have been taken place to estimate and examine the validity of porter's hypothesis.

In todays lecture what I would like to do I you like to share, one of our studies in that contexts, this will give you several new insights about the porter hypothesis, new insights about the

environmental regulation, new insights about the alternative mechanism in the context of developing countries like India. So, the title of our paper that I am going to discuss today is that is win-win opportunity always result in pollution abatement and application of directional distance function to Indian cement industry.

Why we have taken Indian cement industry for our study, because cement industry is one of the most polluting industries in terms of CO2 emission. That is why we would like to examine the role of the regulation in the context of cement industry. And specifically we will throw a special light we will set light on porter hypothesis per say. This particular article has been published in the journal of developing areas, those who are interested more and detail about the paper can go through, here I would discuss only the crux of the story that means, the paper in brief.

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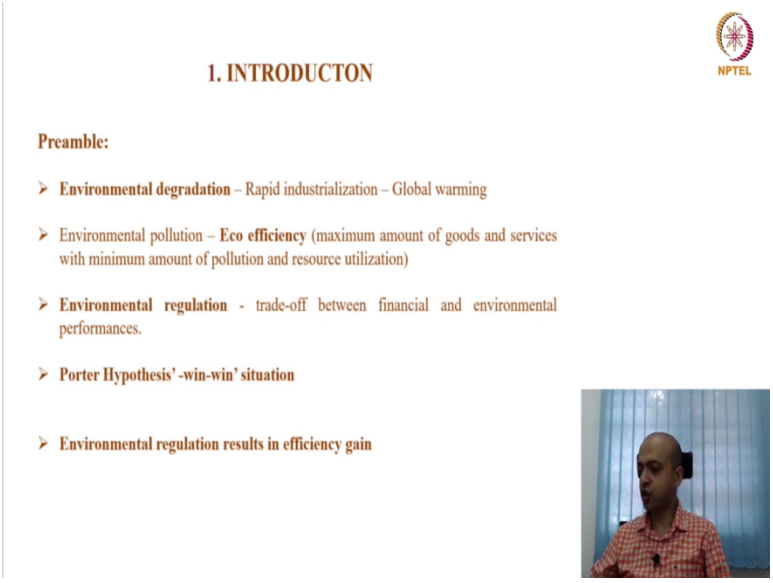

Now, before we discuss about the paper, a brief preamble, the background as you know, that industrialization to achieve higher economic growth has been the major policy objectives of almost all the economics and as a result of which environmental degradation has been inevitable consequence of such industrialization leading to global warming and climate change.

So, what is required now is growth in terms of producing more goods and services with accountability. That means, we need to the productive units must be eco efficient, they need to produce maximum output with minimum undesirable by products. However, such accountability

from the producers point of view cannot come automatically. Why? Because, if you think of the benefit of pollution abatement is mostly enjoyed by the society at large while the cost is in code by the private firms.

So, when the private firms objective is only to maximize their profit, natural question is then why should they become eco efficient? Why should they go for pollution abatement in that context porter hypothesis. It emphasizes the role of regulation, which says that regulation is not always bad forms need not sacrifice their financial performance in terms of profit revenue, so on and so forth as the think because the forms they believe that pollution abatement requires diverting some of their productive resources to pollution abatement from production of goods and services.

So, complying with the environmental regulation and standard will definitely reduce their competitiveness compared to others who are not subjected to such compliance. So, in that context, porter say that regulation may result in innovation and therefore, the firms can actually become more productive efficient. Their productive efficiency may go up, their environmental efficiency may go up, they may produce higher amount of output at the same time they may be they might be able to reduce their pollution. So, this is the preamble. In that context, we will empirically examine what happens to Indian cement forms if we impose any such regulation.

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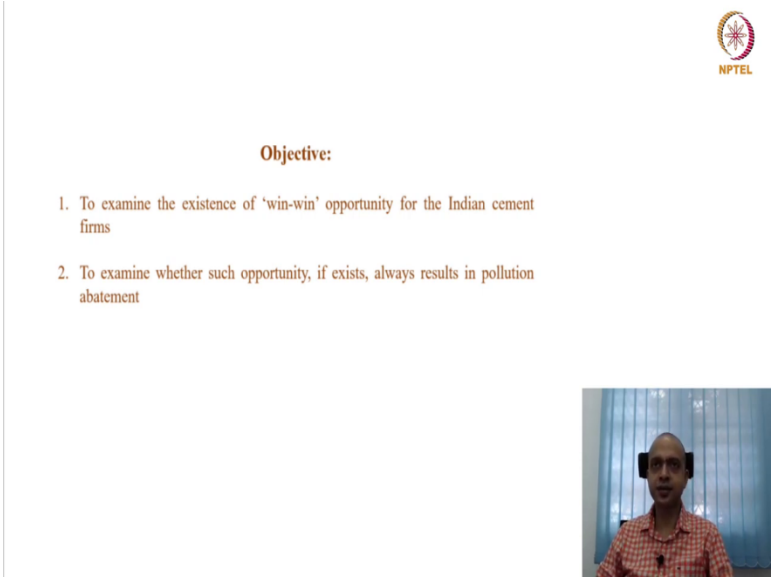

2. ANALYTICAL METHODOLOGY

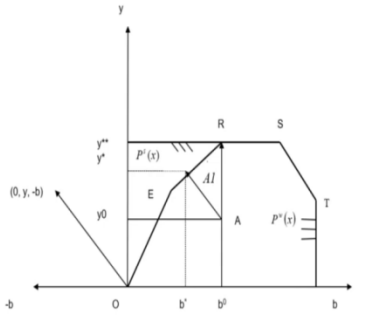

Fig. 1: Directional (technology) distance function and environmental regulation

So, there are two objectives in this paper. Firstly, to examine the existence of any win-win opportunity for the Indian cement firms, that means, whether regulation results in higher amount of output and lower amount of pollution. Secondly, which is more important, while most of the existing studies, they examine the validity of water hypothesis in terms of checking the existence of such win-win opportunity. What we are going to do is to examine whether such win-win opportunity, even if it exists can always result in pollution abatement or not.

And we are going to discuss our argument applying a methodology adopted from data envelopment analysis which is based on production economics. I am not going to discuss in detail about the methodology the mathematical formulation, because that is quite involved. Those who are interested may kindly consult with our detail paper as I have already cited previous. Now, why production economics here if you recall in our micro economic theory, we studied about production function, what does the production function says. Production function says that it is a relationship between input bundle with maximum attainable output given the technology.

Now, the question that comes to our mind is how to decide about the maximum at enable out who will decide that in that context production economics becomes handy production economics they developed a tool wherein they collect the input and output information for all the firms for a given industry. Then, they construct one frontier based on the best performance in the industry.

The firms who are operating on the frontier, they are called efficient the firms who operate inside the frontier, they call inefficient, the means for the inefficient firms it is possible to reach the frontier and thereby gain efficiency without using no further input and without using no further monetary without incurring further monetary cost. Now, we will discuss that our argument based on this simple diagram in this diagram.

In this diagram we have constructed one such frontier O R S T b this is the frontier in the y-axis we measured good output y which is cement in this context, in the x-axis this b indicates undesirable byproduct which is carbon dioxide in this context. Now, if you look at the very shape of the frontier production frontier or this is also called as output set that as undesirable output increases initially production of cement also increases.

But then at a certain state it is constant and then the output comes down and the productive units produces more and more CO2 only. This is purely related to the structure of technology the structure of technology is such that after some point of time you will generate more and more CO2. So, there are two outputs it here one is called a regulated output set that means, we assume the presence of environmental regulation that means, the firms they need to dispose their waste or bad output in a costly manner because any type of disposal pollution abatement is costly.

However, we have constructed another frontier which is called unregulated frontier which is given by O y double star R S T B obviously, the size of the unregulated output set is much bigger than the regulated output set the logic is very simple, because when there is no regulation when the firms are unregulated, then they can simply dispose their bad in the environment freely. So, disposal of bad is a free activity while in presence of regulation, such disposal is a costly activity. So, this is called regulated technology.

Now, what we will do the way we have drawn the diagram you can look at that there is only one common point between the output set and the y axis which is 0. That means, if the firms they want to reduce the bad output they need to reduce their good output also. So, if they want to produce 0 amount of undesirable output or CO2, they should actually stop their production, no production of cement is pursued without reducing minimum amount of CO2 and that property in the language of production economics is known as null jointness null means 0 null jointness

means that means the firms can reduce their bad output only by reducing the caught and then we also assume in this case.

Let us assume that initially the firm is point A. Initially the firm is at point A producing b0 amount of carbon dioxide and y0 amount of cement. In this context if the regulation is imposed and the firms that go for pollution abatement, then what will happen the firm can reach the frontier by A A1 direction and then what will happen when the firm reaches to the frontier, the amount of bad output reduces from b0 to b star the amount of good output increases from y0 to y star.

That means, this simple diagram can indicate that regulation can result in a win-win opportunity because by moving to the frontier by being environmentally efficient the firm can reduce their bad output and increase their good output. So, A A1 in the literature is called direction vector. So, that means a specific direction through which a firm is trying to reach the frontier with an objective to become efficient.

Now, the question is, is there any guarantee that the firm will always move into a one direction, if you look at the direction vector is this and it is defined as 0 y minus b why this is so, 0 means, they are not reducing the input at all neither they are increasing also. Now, y with a positive coefficient indicates they are increasing the good output and minus b indicates they are reducing the bad.

So, in this study we have defined environmental efficiency in this way capability of the firms to increase their good output reduce their bad by same proportion, why we have assumed same proportion because of simplicity sake, if we assume same proportion then it is easy to estimate from the mathematical formulation. Let us not go into the detail of the mathematical formulation which is not possible to discuss in one lecture, but what the point of what we were discussing a movement firm A to A A1 direction helps the firm become more efficient and enjoy win win opportunity.

But is there any guarantee that the firm will always move in A1 direction, rather there is one more option available to the firm. What is that option? The firm can always move to AR direction and when the firm is moving to AR direction then what is happening the firm is

maintaining its pollution level as its as it is, but increasing the bad. Now, the question is how is it possible when the regulation is there, you must comply with the standard then how is it possible for the firm to keep the pollution level as it is that means at this low level?

Yes. it is possible. See, effectiveness of any regulation depends on how do you implement now, it is possible sometimes for the firms to go for some illegal negotiation with the pollution control authorities that means, the officers who come to monitor the firms performance, the firms can easily bribed them to bypass the regulation. So, that they can only increase their good output and keep the bag as it is if they do so, then the firm can produce a good output which is y double star.

Now from the diagram it is very clear when the firm is moving to AR direction, then the expansion in good output y double star which is a higher than y star that means, when the firm were was moving to A A1 direction they were producing only y star amount output. But now, keeping the pollution as it is and moving to AR direction they are enjoying even higher output. Now, the question is, is it feasible economically for the firms to go for the illegal negotiation?

Yes, it is feasible if the value of the extra output that means, if the value of y double star minus y star is more than what the bribing amount the firm needs to pay, then firms should always go for AR direction, not A A1 direction because the firms have to pay a fine when they are caught and there is no 100 percent guarantee that just because there is a regulation, monitoring authorities will always be able to catch this violators.

There is only a probability that a particular firm if they are not, complying with the standard they will be caught and if caught then only there is a question of fine and they can avoid the fine by bribing the monetary authorities. So, these firms can always calculate what is the expected probability? What is the expected bribe that they need to pay, expected fine that they need to pay based on their experience.

So, that is how they will calculate the expected benefit, expected cost and if the expected benefit is higher than the expected cost, then it is always beneficial for the firm to move AR direction rather than moving to A A1 direction even though there is win-win opportunity. That is how with

this simple diagram, we argue that win-win opportunity may not always result in pollution abatement.

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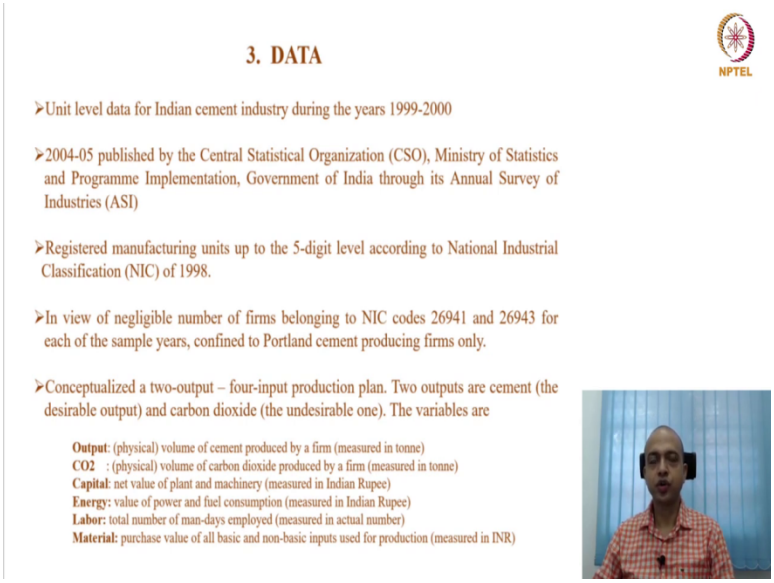

Now, this particular hypothesis we have tested using empirical data from cement industry, we have used unit level data produced by annual survey of industry for the period of 1999-2000 to 2004-05 and what we did we measure output by metric ton of cement and then CO2 by tons of CO2 carbon dioxide produced, then we have used other inputs in the production as capital energy labor and materials.

However, CO2 emission data is not readily available at the firm level at the factory level. So, what we did, we estimated the emission data from the fuel information how much fuel use coal and other things based on that coal oil and other things based on that we follow IPCC guideline intergovernmental panel for climate change what they do they provide some kind of guideline to convert the fuel data into emission data. That is how we have indirectly constructed CO2 emission data.

And then this is the summary statistics of all our inputs and outputs in this context we consider CO2 as an undesirable output. So, that means we conceptualize a two output four input production function. So, one output is cement that is called good output or desirable output another output is CO2 which is undesirable byproducts undesirable output with detrimental impact on the environment and then there are four inputs capital, labor, energy and material then

this is how we have estimated the mean efficiency scores of the Indian cement firms. These are all number of observations.

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3.1 Estimation of CO_2 Emissions

Table 1: Summary statistics of the variables

Year 1999-00	Output	CO2	Capital	Labor	Material	Energy
n	48	48	48	48	48	48
Mean	927385.98	382420.29	1299030375	39608.688	177505126	583289427
Median	706978.5	295635.19	691024029	29786.5	152655273	501090785
SD	759561.21	375135.5	1596345913	31630.962	123775739.9	410272445
Minimum	8797	277.3407	2386751	1703	7531001	6878627
Maximum	2739779	2026431.1	7051508621	172561	545360625	1524906933
Year 2000-01						
N	68	68	68	68	68	68
Mean	805827.4	357296.8	1253833568	157016.72	181040263.3	508355136
Median	556220	279489.47	651781459	126003.5	154584707.5	423299663
SD	707537.78	346744.93	1696710055	116932.27	139930456.8	413040288
Minimum	10	54.968427	2015558	3021	5378516	2938635
Maximum	2663070	1866765.3	7290933000	491747	543004987	1485505236
Year 2001-02						
N	64	64	64	64	64	64
Mean	844554.48	392244.82	1335499294	156107.56	1765051211	568263986
Median	606990.5	277568.07	649394994.5	132712	991103585	404161294
SD	708608	374742.11	1911946893	110561.19	2323779560	492237653
Minimum	2308	79.954076	1731395	2701	7844445	1946691
Maximum	2618768	1736705	11380887241	586008	14645672282	2398432139
Year 2002-03						
n	104	104	104	104	104	104
Mean	1244527.1	329781.14	1144550015	142868.69	2050458222.1	491055242
Median	545965.5	184985	509972453.5	123439	147948511.5	350796690
SD	4628487.3	369365.42	1563704491	124687.34	2014125876	516807571
Minimum	2069	7.4956946	34518	1808	475706	1856368
Maximum	47180000	1594309.3	6792400000	815329	9760160722	3018679571

NPTEL

Year 2003-04						
n	106	106	106	106	106	106
Mean	2197692.8	328502.41	899489397.3	118462.7	177579970.5	413660620
Median	371810.5	133923.08	229086743.5	79192.5	86652990	201433424
SD	15300770	452962.82	1387998892	119515.35	230517881.9	517063446
Minimum	1942	104.93972	173310	1139	685277	873436
Maximum	157945000	2103062	5903542040	506186	1212649832	2813916068
Year 2004-05						
n	93	93	93	93	93	93
Mean	1038397.3	436470.74	1287204259	160681.09	314235237.9	651398965
Median	750552	305072.27	513958125	132695	194405339	459185039
SD	1086844.7	496100.53	1858388273	119309.59	487049275.5	705627494
Minimum	2112	49.971298	302495	1781	1509643	1541334
Maximum	5250621	2316896.7	9636497364	504464	3817270589	4527756536

4. EMPIRICAL FINDINGS / RESULTS&DISCUSSION

Table 2: Summary statistics of the efficiency scores

Year	Under Model 1	Under Model 2	Difference in efficiency scores
Year 1999-00			
Mean	0.3946	0.6736	0.2791
Median	0.2535	0.3109	0.0575
SD	0.3934	1.8027	
Minimum	0.0000	0.0000	
Maximum	0.9980	4.5210	
Year 2000-01			
Mean	0.2038	0.5012	0.2974
Median	0.0786	0.2283	0.1497
SD	0.2871	0.9045	
Minimum	0.0000	0.0000	
Maximum	0.9989	5.793	
Year 2001-02			
Mean	0.2989	0.6282	0.3293
Median	0.1095	0.3973	0.2078
SD	0.3188	0.6735	
Minimum	0.0000	0.0000	
Maximum	0.9584	2.345	
Year 2002-03			
Mean	0.2778	0.5277	0.2499
Median	0.2185	0.2229	0.0044
SD	0.2927	0.7929	
Minimum	0.0000	0.0000	
Maximum	0.9785	4.0650	
Year 2003-04			
Mean	0.3276	0.6422	0.3146
Median	0.2100	0.3718	0.1618
SD	0.3370	0.7553	
Minimum	0.0000	0.0000	
Maximum	1.0050	3.0010	
Year 2004-05			
Mean	0.7137	0.7908	0.0771
Median	0.6162	0.6486	0.0324
SD	0.3416	0.8036	
Minimum	0.0000	0.0000	
Maximum	0.9998	2.838	

Table 3: Wilcoxon's Rank Sum Test Results

Year	Wilcoxon's statistic	1-tailed p value	Decision
1999-00	249	0.8526	Do not reject the Null hypothesis
2000-01	102	< 0.0001	Reject the Null hypothesis
2001-02	67	< 0.0001	Reject the Null hypothesis
2002-03	200	< 0.0001	Reject the Null hypothesis
2003-04	214	< 0.0001	Reject the Null hypothesis
2004-05	622	0.0004	Reject the Null hypothesis

And this is the efficiency score under model 1 and model 2. Model 1 indicates when there is no regulation and model 2 indicates when the firm is bypassing the regulation and moving towards AR direction and we have also calculate the difference.

So, we have calculated efficiency following two model, in one model firm is for moving to A A1 direction. That means, they are reducing the bad and increasing the good in model two, they are increasing the good keeping the bad as it is which in the literature of data envelopment analysis called strong disposability at an assumption. Then we have calculated the difference in the mean efficiency.

After estimating the mean difference in mean efficiency we have also adopted one statistical test called Wilcoxons Rank Sum Test to test whether the mean efficiency scores derived from model two is significantly larger than mean efficiency scores derived from model one why we have used Wilcoxons Rank Sum Test which is a nonparametric test instead of T test, because here efficiency scores are derived from mathematical models.

That is why Wilcoxons Rank Sum Test which is a nonparametric test to check the difference between two series of efficiency scores and then the result soars apart from 1999, in all other years, our null hypothesis got rejected. What was our null hypothesis that there is no significant difference in the efficiency score.

Once it is rejected, that means, we can say that mean efficiency scores derived from model two is significantly higher than model one that means, the firm enjoys significantly higher amount of output if they move A R direction. That means, in a situation wherein firms are trying to only increase their good output, keeping their bad as it is, and these points out to our hypothesis that win-win opportunity may not always result in pollution abatement.

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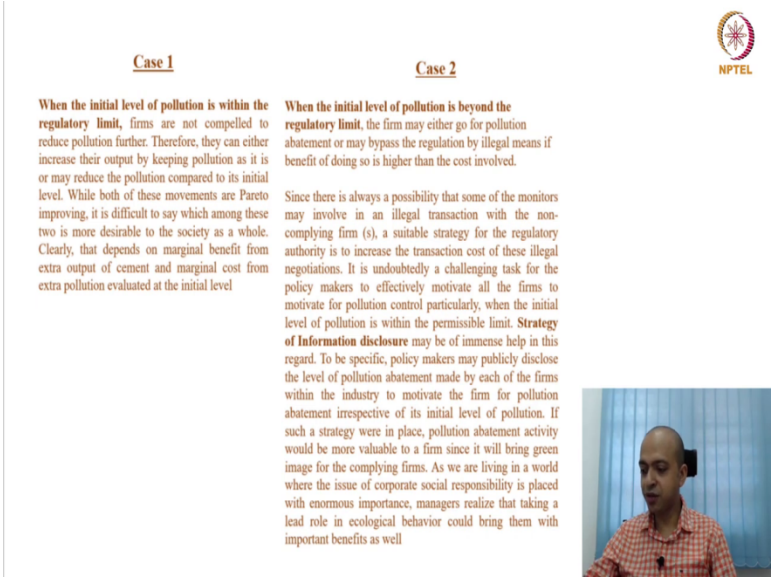

But then what is the solution? The solution is, we have examined two alternative scenarios. Let us first assume the case one in terms of the diagram, I will go back to the diagram once again, we

first assume the initial level A is within the regulatory limit. That means, whatever the firm is producing in terms of the bare CO2 that is within the limit for example.

Let us say that if the standard says that 10 kg of CO2 use the firm is allowed to produce per ton of cement let us assume that the firm is producing only 8 kg of CO2 per ton of cement. So, that means we can say that the initial position of the firm is within the regulatory limit. And if it is 12 kg of CO2 per ton of cement, then we will say that the firms initial position is beyond the regulatory limit.

So, we will discuss the implication of these two alternative scenarios when the initial level of pollution is within the regulatory limit then obviously, the firms have no motivation to go for pollution abatement firms are not compelled to reduce their pollution further. Therefore, they can either increase their output by keeping pollution as it is or they may reduce the pollution compared to initial level and move to A A1 direction.

Now, both these moments are pareto efficient, because in both cases, they are either getting more output or getting more output and lower amount of pollution. So, that means a movement through AR or a A1 both are Pareto efficient, because both are showing an efficient solid situation because they are reaching to the frontier. Now, which particular movement, the firm will choose that is very hard to see in this context, because that depends on the marginal benefit from extra output and marginal cost from extra pollution evaluated at the initial level.

So, firm will calculate what is the marginal benefit and marginal cost. Without knowing that it is very difficult to come to a conclusion which particular path the firm will choose to reach the frontier only one thing we can say that both are pareto efficient, but when it is within the regulatory limit firms are not compelled to go for pollution abatement.

Now case two, let us assume that the initial situation is beyond the regulatory limit and in this context, the firms have two options. The firm can either go for pollution abatement or they can bypass the regulation through some illegal means. If the benefit of doing so, is higher than the cost involved. What is the cost? Cost is there is a probability that you might get caught and you might have to pay some penalty.

So, firm will calculate the expected penalty and the benefit they will compare that and that will help them decide what to do to go for pollution abatement or to go for increasing output keeping pollution as it is by illegal means. Now, the question here, since there is always a possibility that some of the monitors that been monitoring agencies, the authorities, the officials who come for monitoring may involved in an illegal transaction with the non complying firms.

The policymaker can increase the transaction cost of such illegal negotiation that means they can increase the fine. So, even if you the probability is only 110, if the fine is huge amount, then that can motivate the firm to stay away from the such illegal activities. It is undoubtedly very challenging task for the policymakers effectively motivate all the firms then to go for pollution abatement particularly.

So, when the initial level of pollution is within the regulatory limit. However, one alternative solution, we may think of. What is the solution? The solution is information disclosure strategy of information disclosure that means to be specific; the policymakers may publicly disclose the level of pollution abatement by each and every firm the pollution controlling authority may disclose their performance by giving them some green rating.

And if such disclosure of performance happens, then what will happen the firm will get some benefit from pollution control which they were not getting earlier due to this green image what they will have what it will help them this green image of the firms will help them creating a good reputation in the public.

So, when these firms they go for financing in the capital market, the capital market may give a positive feedback to those companies, which are environmentally sound. The customers can prefer those companies output which are environmentally sound that means a good environmental performance. A good environmental image can benefit this firms to go from their pollution abatement activities.

When we are living in a world where the issue of Corporate Social Responsibility is placed with enormous importance, managers they realize that taking a lead role in ecological behavior could

bring them with important benefits. So, nowadays corporate social responsibility. So, that means doing business in a socially responsible way is becoming more and more important.

Regulators are now imposing a rule that if your turnover annual turnover exceeds a certain level, then you must invest some amount of your money in a core socially responsible way. If that is the case, then this pollution disclosure or disclosing the firms performance about their abatement would lead to could benefit them by providing an extra age.

So, that is why we argue that in a country like India, will formal regulation in the form of emission tax or command and other command and control mechanism fails. Due to improper monitoring these type of informal regulation in the form of information disclosure may help them go for help them and induce them for better environmental performance, which is very, very helpful for developing countries like India, because we do not have that much of the resources to monitor the firms performance in terms of their pollution control activities.

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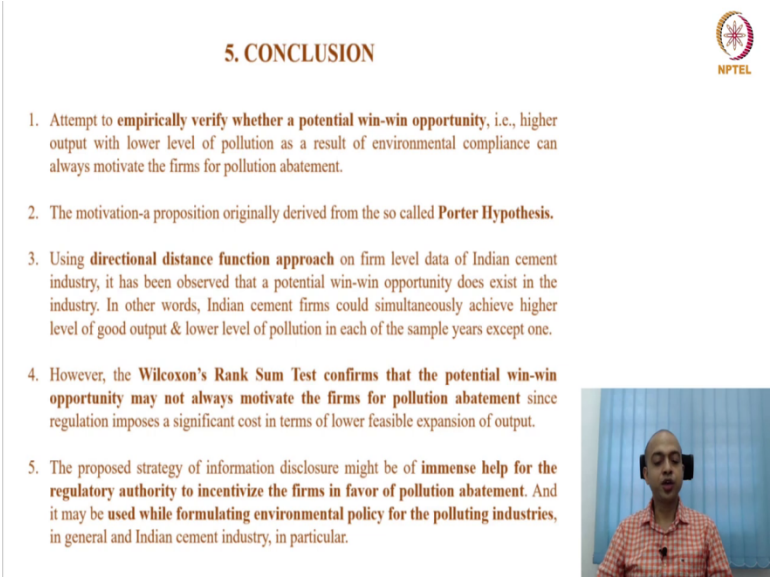

So, in short, what we did in this paper we made an attempt to empirically verify whether a potential win-win opportunity that means a higher amount of output with lower amount of pollution is possible as a result of environmental compliance. And whether such win-win oppurtunity can always motivate the firms for pollution abatement.

And the motivation comes from the proposition of Porter hypothesis, we use mathematical model namely the directional distance function approach on firm level or factory level data in the context of Indian cement industry. And it has been observed that a potential win-win opportunity does exist in the industry.

That means, they could increase their good output, reducing their bad if any such type of regulation was imposed. However, Wilcoxons Rank Sum Test confirms that such potential win-win opportunity may not always result in pollution abatement. Since regulation imposes a significant cost in terms of lower feasible expansion of output.

We propose a strategy of information disclosure which might be of immense help for the regulatory authorities to incentivize the firms in favor of pollution. And it may be used while formulating environmental policy for the polluting industries in general and Indian cement industry in particular. Thank you.