Environmental and Resource Economics
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Lecture 39
Economic Valuation of Environmental Goods and Services – Different Valuation Approaches Part – 3

So, that is the problem of this closed ended referendum. But, even then since it is easy to estimate most of the literature empirical literature they use closed ended referendum, only for CVM kind of study for estimating mean WTP. So, let us now discuss about how actually we go about estimating the mean WTP function.

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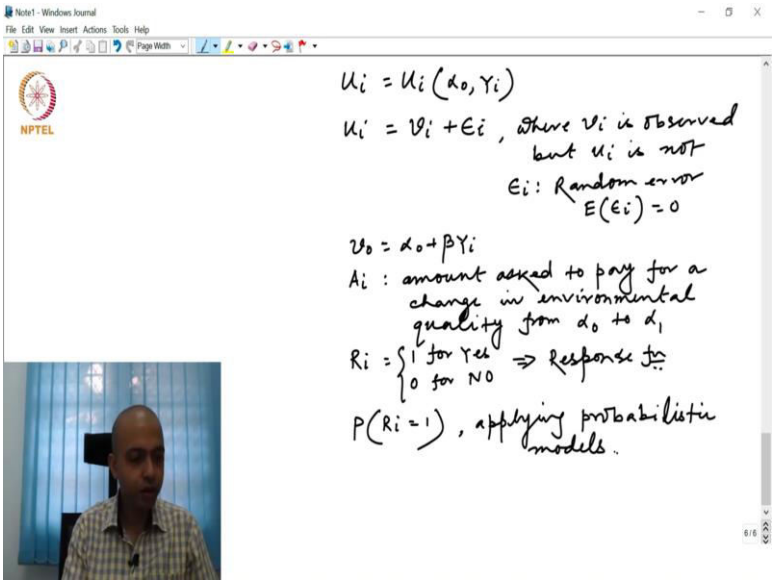

So, once again we assume that utility of the let us say the ith individual is a function of let us say initial environmental quality y0, and let us say individual have an initial income which is Yi. Now, this utility Ui is something which is unobserved; that is why utility we can write as Vi plus epsilon i.

Even if we know what is the environmental quality, even if we know what is the individual's income; it is not possible to observe individual utility. Utility is something which is unobserved; because since it is unobserved, we decompose utility into two components Vi; which we assume is observed and with some random error term epsilon i to make a sense that utility is unobserved.

So, we say that where Vi is observed but Ui is not. And epsilon i is a random error term and the assumption is that expectation of ui; sorry, expectation of epsilon i equals to 0 that is the

assumption we mean. So, this Vi is written as let us say alpha0 plus beta into Yi. So Vi is a linear function in environmental quality and the composite good, which is income.

And Ai is the amount asked, let say Ai amount asked to pay for a change in environmental quality, from alpha 0 to alpha 1. From alpha 0 to alpha 1 we will ask the respondent in a specific amount; Ai may be 50, 150 or 200 rupees. And then we will have a response function like this. Response function is 1 for yes and 0 for no; so this is called response function, that is response function. So, that means here the respondents will either say yes or no.

And our objective here is to apply a probabilistic model from the econometric literature; so that we can actually estimate what is the probability that the individual will say yes for a specific bid amount asked, given the individual socio economic and demographic characteristics. So, that means the individual will say yes for a specific bid amount, given the individuals income, maybe individuals age, individuals gender, religion so on and so forth.

And we have to use all this information to estimate what is the probability that the individual will say yes for a specific bid amount. So, that means we are going to estimate the probability that Ri takes the value 1, Ri takes the value 1. That is what we are trying to estimate applying probabilistic models. Now, what is the probability that the individual will say yes?

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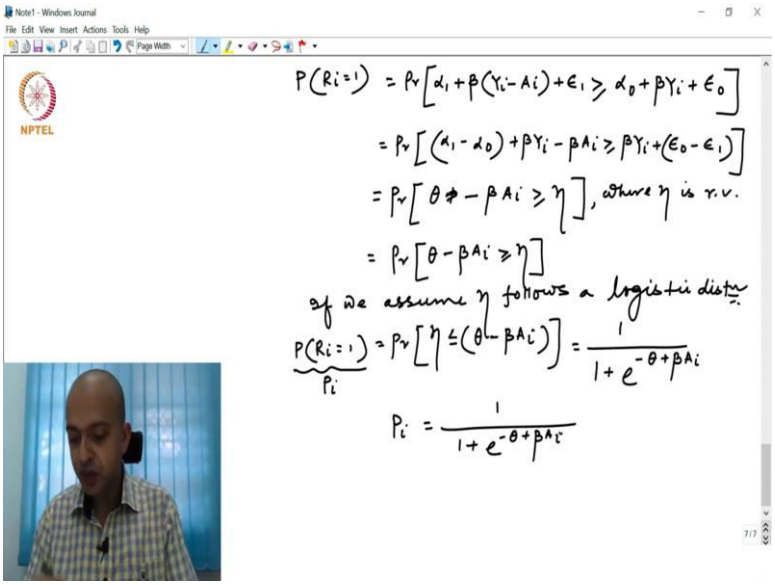

So, when you say probability we are trying to estimate probability that Ri equals to 1. Individual will say yes for a specific bid amount Ai, when it is asked to pay what is the probability; that can be easily estimated in this way. This is nothing but probability, let us say

in the new scenario, your environmental quality is alpha1; because that is the change has been made in the environmental quality.

Environmental quality improved from alpha 0 to alpha 1, and then for that you are asked to pay some A amount; so, your income is then Yi minus Ai, and then that random error term. So, that means in a new scenario in the new scenario when environmental quality improves from alpha0 to alpha1. What would be your utility? Your utility would be alpha 1 plus beta into Yi minus Ai plus epsilon I; because that is how we have defined our utility.

Utility is basically how we have defined? A summation of Vi plus epsilon i; this alpha1 plus beta into Yi minus Ai is the Vi function; and then we are adding the random error term. So, individual will say yes to a specific amount Ai for an improvement in environmental quality from alpha 0 to alpha 1, if the individual's utility with alpha 1 environmental quality and Yi minus Ai amount of income is greater than or equals to the initial utility, which is alpha 0 plus beta into Yi, plus epsilon 0; which is very simple to understand.

So, basically alpha 0 plus beta into Yi plus epsilon 0, it is the initial utility; and alpha 1 plus beta into Yi minus Ai plus epsilon Yi that is the terminal utility. So, that means this is utility at the initial stage, this is utility at the terminal stage. So, individual will say yes, if utility with alpha 1 amount of environmental quality is greater than or equals to this. So, this we can write as probability then what we will do?

This will say that alpha 1 minus alpha 0; and then this would become beta into Yi minus beta Ai is greater than equals to beta Yi, plus epsilon 0 minus epsilon i. Let us now assume that this alpha 1 minus alpha 0 is theta; so this is this becomes theta plus beta Yi beta Yi will get cancelled out.

So, this would become theta, sorry this would become minus actually; so this is not plus theta minus beta Ai. Theta minus beta Ai greater than equals to let say epsilon 0 minus epsilon 1 is nu. So, that means this is or where nu is basically, where nu is a random variable; nu is a random variable.

So, ultimately this is probability theta minus beta Ai greater than equals to nu. Now, if we assume nu follows a logistic distribution logistic distribution; then what we can write that probability, that means we can write probability Ri equals to 1, equals to probability I can say that nu is equals to less than equals to theta minus beta Ai.

This equals to actually let us say that this equals to this probability Ri equals to 1; we are defined as Pi. That means we can say that in the literature of probability we can say that Pi is probability that the event will happen. So, this Pi equals to then we can write 1 by 1 plus e to the power minus theta plus beta Ai.

So, we can write Pi equals to 1 by 1 plus e to the power minus theta plus beta Ai; this is the probability. So, this is like a logistic regression function which is there in econometric literature. So, what I will discuss in detail about the logistic regression also in this context.

So, that it becomes easier for you to understand what is a logistic function, and how to estimate logistic function. Because without understanding the logit model, it would be difficult for you to understand how will you estimate the average WTP. Now, from here in the next step what we do?

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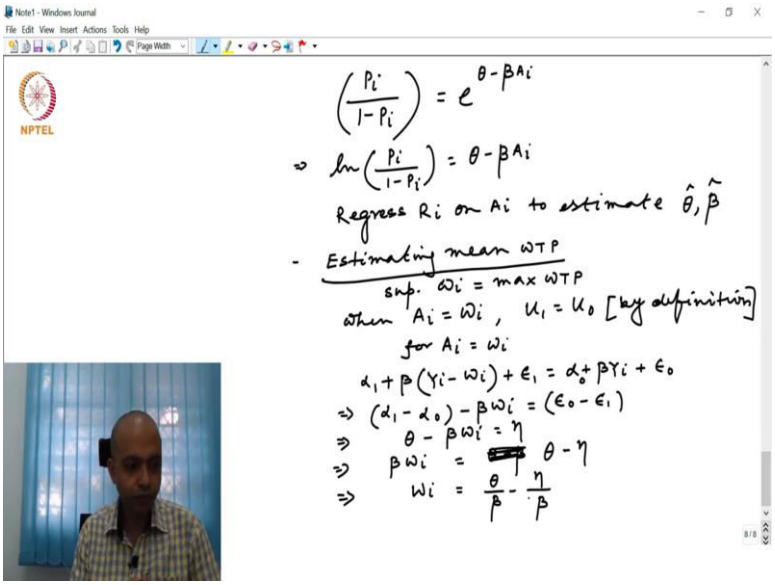

Once you estimate the Pi. So, next step what you have to do, you have to calculate this Pi by 1 minus Pi, which will then become e to the power theta minus beta Ai. And this Pi by 1 minus Pi is known as odd's ratio; that means odds in favour of happening an event. And if we take log of both sides, then log of Pi divided by 1 minus Pi equals to theta minus beta Ai, theta minus beta Ai.

Now, how will you so here then our task is to estimate this theta hat and beta hat; these are the two parameters we need to estimate for estimating the mean WTP or mean willingness to pay. So, that means we need to regress the response function Ri on the bid amount Ai, and any other additional variable.

For the time being we are not considering any additional variable here. So, what we will do will regress Ri on Ai to estimate theta hat and beta hat. So, once we estimate this function this theta hat and beta hat; then next step is estimating mean WTP. So, next step is estimating mean WTP; how will you do that? So, for this purpose let us assume suppose Wi is the maximum willingness to pay; Wi is the maximum willingness to pay.

So, when this Ai the amount what we are asking the respondents to pay is equals to the maximum willingness to pay Wi. Then what will happen? When Ai equals to this, then you can write that U1 equals to U0; so, utility at the initial stage utility at the final stage that would be equal; because that is by definition only by definition.

Since, I am paying the maximum, so that means after paying that amount what will happen? My utility what I was enjoying earlier and my utility now with improved environmental quality is same; because maximum willingness to pay is my, is my entire consumer surplus in terms of the demand function.

So, when Ai is fixed at the maximum willingness to pay Wi, then utility that means the respondents is indifferent between two states, initial state and final state. So, that means for Ai equals to Wi, what we can write? For Ai equals to Wi; what we can say that alpha 1 plus beta into Yi, minus Wi plus epsilon I; sorry epsilon 1 equals to alpha 0 plus beta into Yi plus epsilon 0 utility are same.

So, from here what we can say that alpha 1 minus alpha, this is alpha 0; alpha 1 minus alpha 0, plus beta Yi and beta Yi will get cancelled out. That means minus beta Wi equals to epsilon 0 minus epsilon 1. So, that means we can say alpha 1 minus alpha 0 is theta minus beta Wi equals to this is nu.

So, that means we can say that beta into Wi equals to theta minus, sorry this is theta minus nu. From here what we can write is that that means Wi equals to theta by beta, minus nu by beta.

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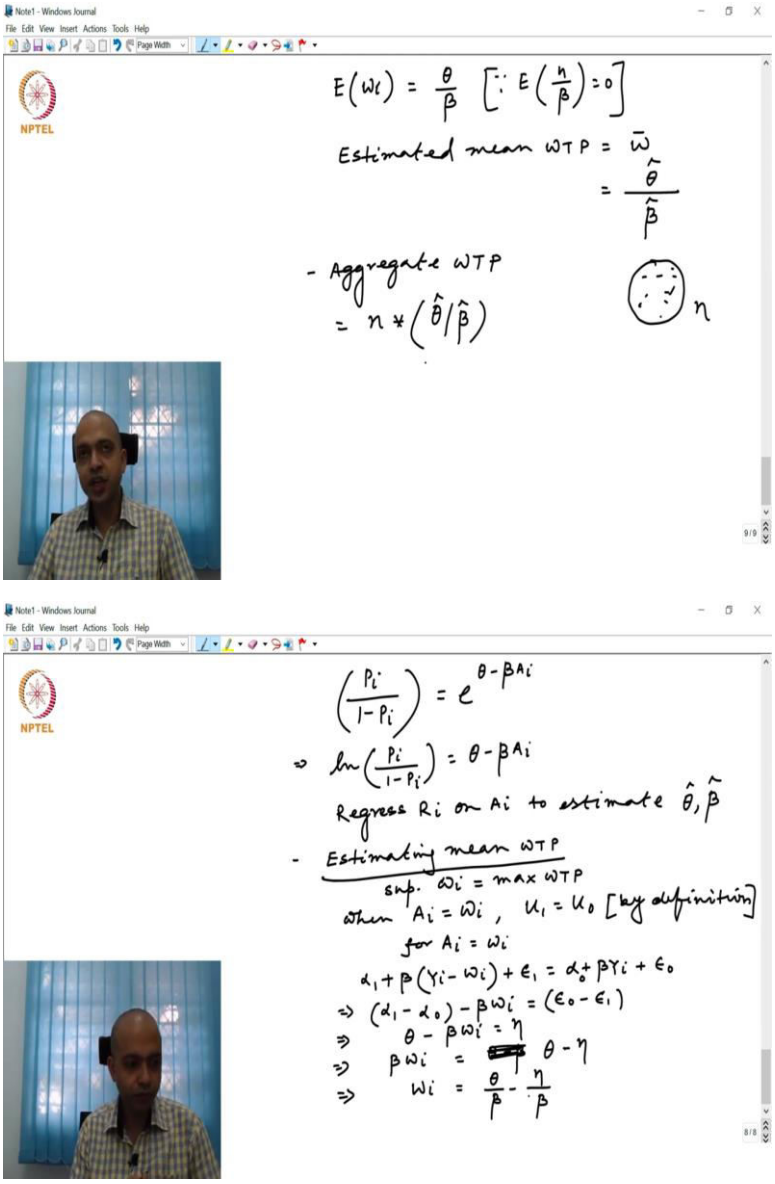

So, from here what we can write the mean WTP then, expectation of Wi is then equals to theta by beta; since, expectation of nu by beta equals to 0, because nu is again a random error random variable. So, that means estimated mean WTP equals to w bar which is equals to theta hat divided by beta hat.

So, that means once we estimate the function in this stage itself, when we regress Ri on this bid amount by applying the logit model; we would be able to estimate the two parameters theta hat and beta hat. And mean WTP is nothing but theta hat by beta hat. Once we estimate the mean WTP, next step is to get the aggregate WTP.

How will you estimate the aggregate WTP? For estimating the aggregate WTP, what we need to understand? Suppose we are estimating the mean WTP for a resource; then we need to

identify the total number of people's, total stakeholders from who are deriving benefits from that particular resource. Let us say there is a resource called wetland and there are n number of individuals who are deriving benefits from the wetland. So, these n numbers of individuals are called stakeholders.

So, once so that means that is your total size of the population who are deriving benefit from these stakeholders. We have collected only a sample representing the entire population. So, that means aggregate WTP would be this n multiplied by theta hat divided by theta divided by beta hat; this is how we need to get the aggregate WTP.

So, this is the mechanism by which we can actually follow the contingent valuation method step by step; this is the contingent valuation method we follow step by step. So, firstly what we need to do? We need to set up a market; and in that market set up we need to provide certain information to the individual about the quality of the good.

How it is going to change the utility? What is the price? And how you are going to collect the money? That is called payment vehicle. These four information we need to provide to the individual. And then after providing the information, next step is collecting the bid.

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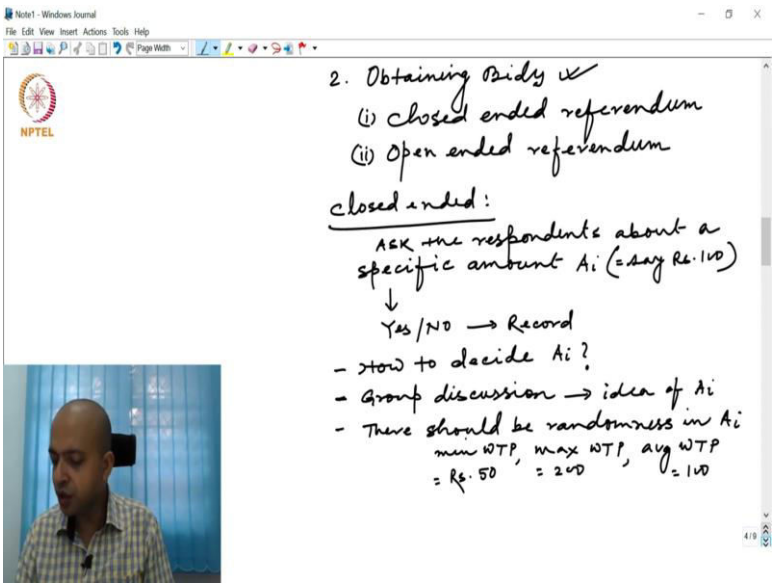

So, if you go back obtaining bids is the second stage. And in obtaining bids, generally we follow two approaches; one is called closed ended referendum, another one is called open ended referendum. In closed ended referendum we simply ask the individuals for a certain amount to pay for a specific amount of utility change from alpha 1 to alpha 0; sorry alpha 0 to

alpha 1. And whatever they say whether yes or no, we simply note down; and that is how we generate the response function.

And how do you this bid amount should be randomized? There should be enough randomness in the bid amount. We should not ask each and every individual or each and every household about the same bid amount. How will you create the random bids? Basically through group discussion.

We have to have a sense of what is the maximum people saying about the minimum value, maximum value, average value. Then carefully we need to select the minimum bid value which should be accepted by all. Then the maximum value which should be rejected by all and then two bid values around the mean.

That is how we can generate some four bids. And then we can divide the entire sample let us say you are going to collect information from 200 individuals; you can divide the entire sample into four sub samples. So, 50 individuals each 50 each bid would be used for 50 individual. So, minimum bid value randomly for the 50, then maximum bid value for another 50; and two average values for another 100 people. But, we need to randomly ask the bid amount.

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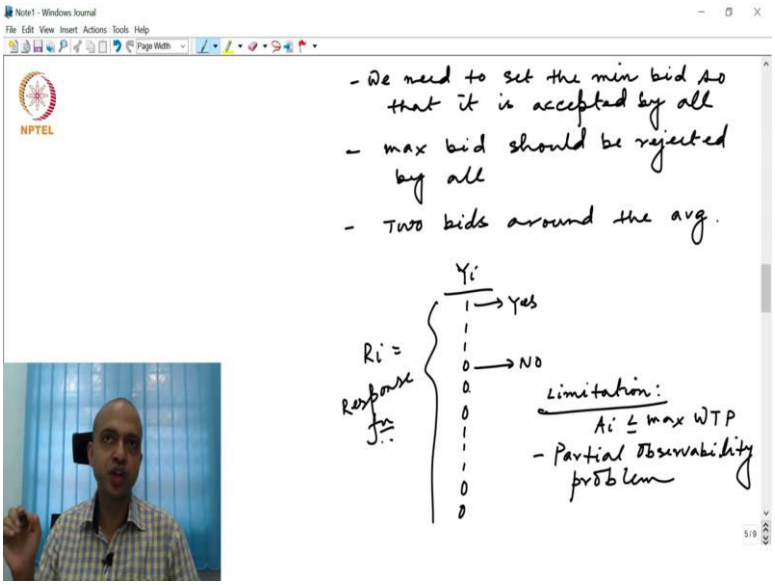

Note1 - Windows Journal

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NPTEL

$U_i = U_i(\alpha_0, Y_i)$

$U_i = V_i + \epsilon_i$, where V_i is observed but U_i is not

ϵ_i: Random error

$E(\epsilon_i) = 0$

$V_0 = \alpha_0 + \beta Y_i$

A_i : amount asked to pay for a change in environmental quality from α_0 to α_1

$R_i = \begin{cases} 1 \text{ for Yes} \\ 0 \text{ for NO} \end{cases}$ ⇒ Response fn.

$P(R_i = 1)$, applying probabilistic models (for ex. Logit model)

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$$P(R_i=1) = P_r\left[\alpha_1 + \beta(Y_i - A_i) + \epsilon_1 \geq \alpha_0 + \beta Y_i + \epsilon_0\right]$$

$$= P_r\left[(\alpha_1 - \alpha_0) + \beta Y_i - \beta A_i \geq \beta Y_i + (\epsilon_0 - \epsilon_1)\right]$$

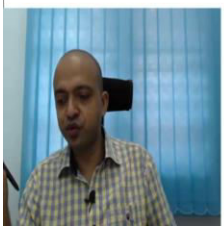
$$= P_r\left[\theta + \beta - \beta A_i \geq \eta\right], \text{ where } \eta \text{ is r.v.}$$

$$= P_r\left[\theta - \beta A_i \geq \eta\right]$$

If we assume η follows a logistic distn.

$$\underbrace{P(R_i=1)}_{P_i} = P_r\left[\eta \leq (\theta - \beta A_i)\right] = \frac{1}{1+e^{-\theta+\beta A_i}}$$

$$P_i = \frac{1}{1+e^{-\theta+\beta A_i}}$$



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Note1 - Windows Journal

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Odds Ratio $\Leftarrow \left(\frac{P_i}{1-P_i}\right) = e^{\theta - \beta A_i}$

$\Rightarrow \ln\left(\frac{P_i}{1-P_i}\right) = \theta - \beta A_i \longrightarrow$ Logit model

Regress R_i on A_i to estimate $\hat{\theta}, \hat{\beta}$

- Estimating mean WTP

Snp. ω_i = max WTP

when $A_i = \omega_i$, $U_1 = U_0$ [key definition]

for $A_i = \omega_i$

$\alpha_1 + \beta(Y_i - \omega_i) + \epsilon_1 = \alpha_0 + \beta Y_i + \epsilon_0$

$\Rightarrow (\alpha_1 - \alpha_0) - \beta\omega_i = (\epsilon_0 - \epsilon_1)$

$\Rightarrow \theta - \beta\omega_i = \eta$

$\Rightarrow \beta\omega_i = \theta - \eta$

$\Rightarrow \omega_i = \frac{\theta}{\beta} - \frac{\eta}{\beta}$

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And then we will generate the response function like this. So, this is your response function which we have defined later on; this is your Ri. There is either 1 or 0, this is called response function. And since it is closed ended referendum, what do we say that this is a partial observability problem is there; because we do not know whether individual is ready to pay even higher than what I asked.

I am simply noting down if I ask 100, the individual will say yes; I will note down that and the story ends there. If the individual say no, I will note down that; and I will put 0 value and the story ends there. So, that means this closed ended referendum suffers from partial observability problem; but still we use that because of its ease for estimation.

And then we assume an utility unction for the econometric estimation, which has two components; one is deterministic, another one is non-deterministic; that means systematic and non-systematic. Epsilon i is a error term which makes the utility function unobservable. So, here in this probabilistic model we have to apply to estimate the probability that the individual will say yes for a specific bid amount.

That means we are interested in estimating probability that Ri equals to 1; and we need to apply probabilistic models like for example logit model. And how it goes probability that individual will say yes, is equivalent to the probability that after paying the specific amount Ai; and with the improved environmental quality alpha 1 individuals utility is higher than greater than or equal to the initial utility.

Then we derive this wherein we are finally we are getting the Pi equals to that probability nu less than equals to theta minus beta Ai. So, that means if we assume that this nu follows a logistic distribution; it comes around 1 by 1 plus e to the power minus theta plus beta Ai, which is nothing but simply logistic cumulative distribution function. So, Pi equals to 1 by 1 plus e to the power this.

From there we estimated one, we transform this into odds ratio; this is called odds ratio. Pi by 1 minus Pi is called odds ratio, and log of Pi by 1 minus Pi is log odds ratio. So, once you take log, then it becomes theta minus beta Ai; which is nothing but a logit model in econometric literature. So, this is a logit model. If we add an error term in this, then this would become a logit model.

So, we need to learn the logit model from econometric literature. And I will discuss in detail about the log probabilistic model, linear probability model and logit model also, to make you

understand the integrities of econometrics of that logit model. So, that you can understand and estimate this type of mean WTP given a particular scenario.

So, we need to regress this is a regression technique; regress your response function Ri on Ai to estimate the two parameters theta hat and beta hat. Once you estimate this, then mean WTP as we derive is nothing but theta by beta equals to nu by beta. So, if you take expectation of this that means average of this; then what will happen?

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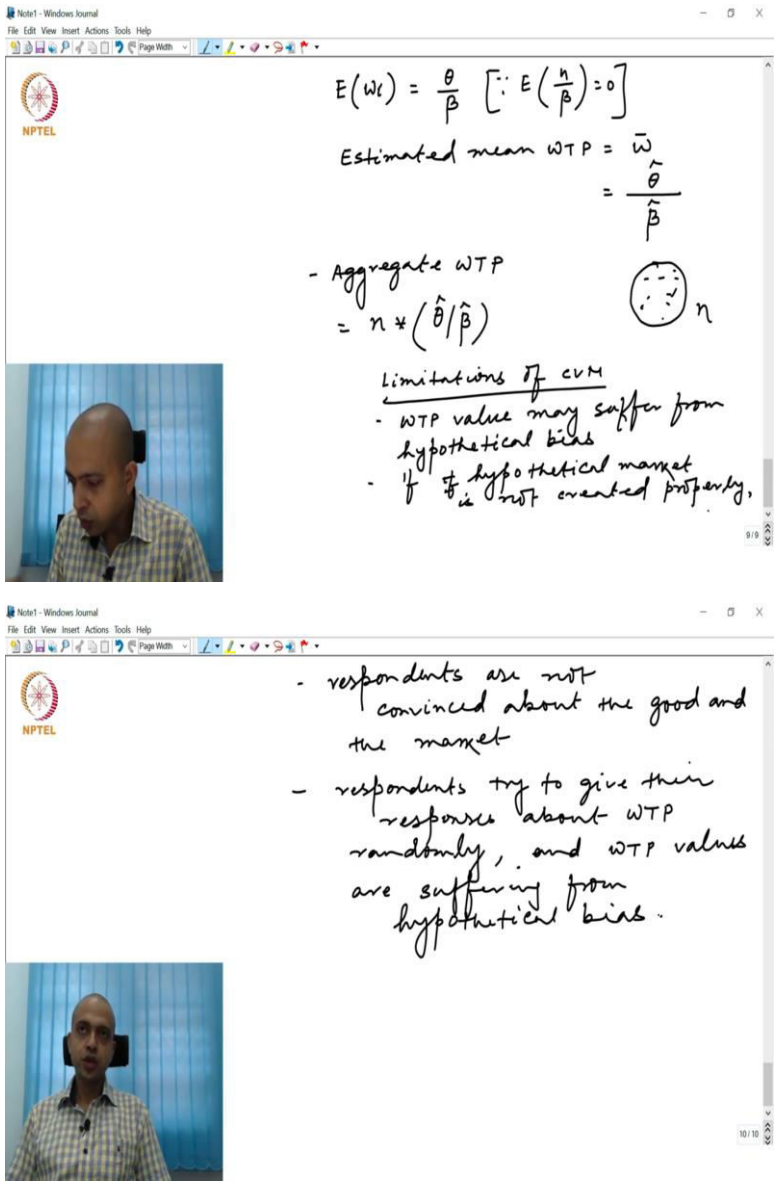

This would become theta by beta; so that means w bar equals to theta by beta hat. So, once you estimate the mean, then what we need to do? We need to identify the total number of individuals who are actually deriving benefits. So, if we multiply that with the total number

of stakeholders, then we will get aggregate WTP. But, this contingent valuation method, there are certain limitations, limitations of CVM.

The major limitation for the time being is that what we are going to discuss is that partial observability problem, which is related to the related to closed ended referendum. And apart from that partial observability problem, the WTP value may suffer from hypothetical bias.

What is this hypothetical bias? See in this contingent valuation method what we do? We create a hypothetical market to elicit the preference of the individual about environmental goods and services. Now, creating that market hypothetical market requires so much of efficiency from the researcher's point of view.

If we cannot create the hypothetical market efficiently; that means if the hypothetical market is not convincing if hypothetical market is not created. If it is not created properly, respondents are not convinced about the good and the market. And if they are not convinced with the good, suppose in the hypothetical market, the kind of commodity or service what you are talking about; the respondents are not very convinced.

So, they are not convinced that this type of good you the government, local government, or authority can actually supply. So, when they are not convinced you are not able to create a sense of the hypothetical market to the respondents; then the respondents will randomly say something.

So, respondents try to give their responses about WTP randomly, and WTP values are suffering from hypothetical bias. So, we need to carefully create the market; we need to clearly tell them what is the good. We have to explain them if they do not have any experience of that type of good earlier; then we have to clearly explain them this is the good.

We have to convince them yes from 50 to 100 liters of water; what we are talking about that is possible to supply. For example, if you are say if you are saying that from you are getting 50 liters from next month itself, you will get one gallon of water. That may not be very convincing, so we need to tell them that yes local municipality or corporation, they have taken a project; wherein their objective is to increase water supply.

But, then corporation needs some amount of support from you as well; so, that is why we are here to conduct survey. So, we have to clearly explain them this is the good, this is how it is going to be supplied; and this is how it is going to change your utility. They may not be aware how they are going to use this, water they can understand. But, sometimes if it is some

other goods from for from which they are not; that for which they are not familiar to, then we need to clearly explain them.

Then what is the price? Then what is the payment mechanism? Everything should be very convincing; then only the quoted WTP value what we are going to collect from the respondents; that would be reliable. Otherwise, it is going to suffer from hypothetical bias. So, these are the different steps that are involved in this type of valuation survey. So, in our next class what we will do? We will discuss the probabilistic model; and I will give you a data set, not exactly in the context of valuation, but some other context.

My objective is to make you understand the estimation of logit model. Once you understand the estimation of logit model that you can apply in any other context; because you are it involves regressing the dependent variable on a set of independent variables. In this context it is Ri on Ai and the data set probably what I will give that is the labor force participation data; whether the laborers are participating in the labor market or not? Yes or no?

That is also another response function regressed on the laborers age, education, experience so on and so forth. Once you understand the estimation part, then given a context if you collect this type of information, bid values randomly; and the respondents income, age, education so on and so forth, you would be able to estimate the function.

Once you estimate the function, you will be getting the two parameters theta and beta hat; from there you can easily estimate the mean WTP theta hat by beta hat. I will also give you a reference for a journal article. There you can if you read them; the example one example a fantastic example is given there to understand how step by step we can actually apply this model; that we will discuss in our next class.

And this so for whatever we have discussed; that you can study from our standard reference book that Hanley Shogren and White. But, first you go through my lecture thoroughly; you will get an idea. Once you get some idea about this model, then you please go back to the text book. So, with this we are closing our discussion today. Thank you.