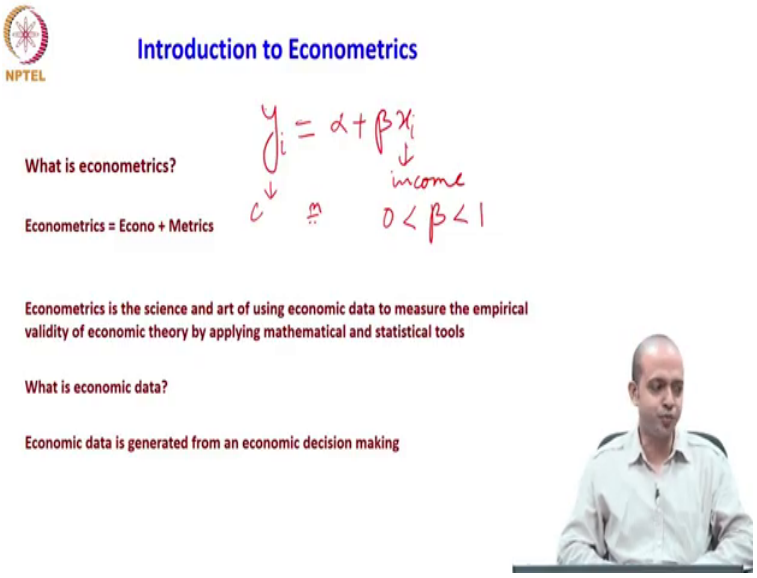
Introduction to Econometrics
Professor. Sabuj Kumar Mandal
Department of Humanities and Social Sciences
Indian Institute of Technology, Madras
Lecture No. 03
Different steps in econometric analysis Part - 1

So, welcome to Introduction to Econometrics, this is going to be a very, very interesting course for you, because in this course, you will not only learn the theoretical steps related to this particular subject, you are also going to learn the computer application of econometrics that means, how several econometrics models can be estimated using statistical software. So, before we discuss in detail about what are the different types of econometric models and all.

(Refer Slide Time: 00:58)



So let us try to first understand what exactly econometrics is and what is the meaning and definition of econometrics. There are several definitions available in the literature but if we combine all those then basically we will come up with a combined definition of econometrics. Then the best possible way to know the definition of econometrics is just to decompose this word into two components. So, econometrics is basically a summation of two components- Econo and Matrics. What is the meaning of Econo? Econo basically stands for Economics and Matrics stands for Measurement. So, if I sum it up, that means econometrics basically indicates the measurement of economics or economic measurement. Now, the next question comes to our mind when we say measurement of economics or economic measurement is what we are actually going to measure in economics.

Basically we are going to use the econometric tools to measure the empirical validity of economic theory. So, that means if you look at the definition, it says, Econometrics is the science and art of using economic data to measure the empirical validity of economic theory by applying mathematical and statistical tools. Now, in this particular definition several important components are used and we need to learn the meaning and significance of each and every component that are used in this particular definition. First of all, it says econometrics is the science. Now, why econometrics is called science? Because in scientific analysis first we observe certain things and then gather data and then try to analyze those data and then you come to certain conclusion. Similarly, in econometric analysis also we will observe certain behavior, particularly some social behavior, and then we will collect data pertaining to those behavior and we will analyze those data and come to a conclusion. What is the objective of that? Objective of that data analysis is to come up with a conclusion so that we can see whether particular economic theory is valid in a particular context or not. Why it is called art? It is also called art because like any other artists, in econometric analysis, you need to learn the art of setting an econometric model that you are going to use and that will come only after several rounds of practice. So once you get little more habituated with the subject and gets a little bit of expertise, you will know what that art is.

It also says that econometrics is the science and art of using economic data. What is economic data? Economic data is basically the data generated from economic decision making. GDP, money supply, rate of interest, inflation are the variables that come to our mind when we first think of economic data but the concept of economic data is actually much broader than GDP, employment, rate of interest, inflation, and other things. So in general if you try to think about economic data in a much broader sense and apply the data generated from decision making into the definition, you will see that economic data not only mean GDP, inflation, unemployment, and rate of interest etc but many other things. That means you can use econometric tools not only to analyze the data pertaining to GDP, inflation, and unemployment but in several different contexts also you can use this particular technique to analyze with an intention to give the empirical validity of economic theory and the tools that we are going to use here are mathematical and statistical tools.

Now let me explain little more about the mathematical and statistical part from this definition. It says econometrics is basically the application of mathematical and statistical tools but econometrics is neither mathematics nor statistics. Econometrics is a distinct subject which is distinct from mathematics as well as statistics. Now, if I give a small example, then

things would be much clearer to you. What is mathematical economics? Generally, we may think of econometrics is mathematical economics. Actually, econometrics is not mathematical economics because the objective of mathematical economics is to represent economic theory using a mathematical model using equations. For example, we all know the economic theory of Keynesian Consumption Function which says that as income increases consumption also increase but less than proportionately. Now, if you want to represent that particular economic theory using a mathematical equation, then it will look like your

$Y=\alpha+\beta X_i + u_i$,

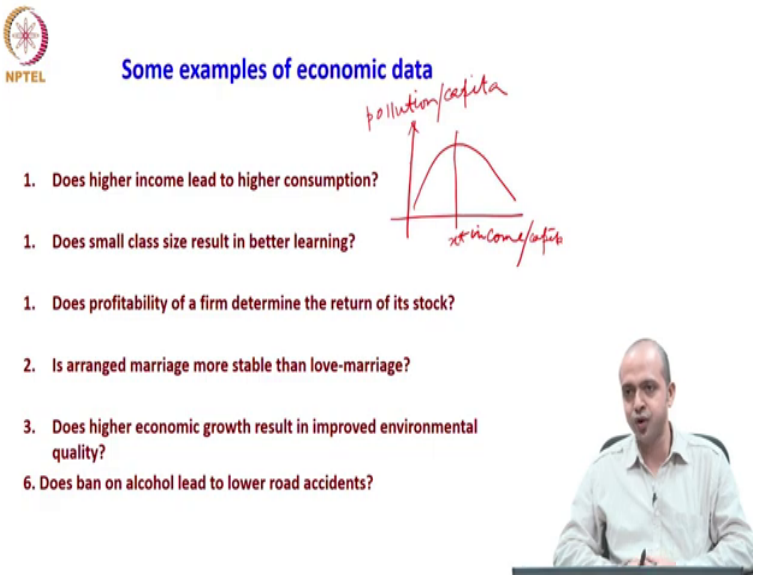
where, Y is consumption and X indicates income. When I say that as income increases consumption also increases but less than proportionately, how will you specify? You have to put a restriction on this parameter beta. So, beta is basically less than 1 but greater than 0. So, I have included 1 error term here that should not be there.

So my model is basically $Y_i = \alpha + \beta X_i + u_i$, where i indicates individual. So, Y_i indicates individual i's consumption-may be weekly, monthly or yearly, and X indicates correspondingly weekly, monthly, or yearly income, and then the restriction I have imposed on beta is beta is greater than 0 but less than 1. So, the job of mathematical economist is done here only. Mathematical economist will never go to check the empirical validity of this economic theory. So, this is called mathematical economics-representing economic theory using mathematical models and equations. Then what is statistics? What is the job of a statistician? After collecting data on consumption and income statistician will process the data and then will also present the data using some charts and tables but statisticians will never use this data to check the empirical validity of economic theory. Someone who does that is actually an econometrician.

So, that means the job of an econometrician is quite different from that of a statistician or a mathematician. Mathematician will build the model using mathematical equation and statistician will collect data on income and consumption-that is a raw data collected by the statistician, and the statistician will represent the data using some tables or charts or diagrams. An econometrician will use that mathematical model and the data collected by the statistician and then try to analyze the data to keep empirical validity of economic theory. That is why the complete definition of econometrics says that econometrics is the science and art of using economic data to measure empirical validity of economic theory by applying

mathematical and statistical tools. This is the complete definition. Now we will see what are the some examples of economic data.

(Refer Slide Time: 12:19)



These are the some examples of economic data. Let us say that the first example is does higher income lead to higher consumption. Here both income and consumption are economic datas because both are generated from some economic decision making like what type of job you will do, how much possible whether you are you will participate in the labour market or not, that is an economic decision making. If you participate what type of job you will take up is also an economic decision making and how much labour you will supply in the labour market is also an economic decision making because you will also be analysing the cost and benefits of participating in the labor market and the cost and benefit of supplying each and every unit of labour in the labor market. Supplying labor and working in the labor market has some opportunity cost. What is the opportunity cost? Instead of working you can take leisure and that leisure time you can spend with your family, you can watch movies, you can go for social networking, so on and so forth.

So, that means, I will work up to that point where my marginal benefit and marginal cost of labor supply is equal. So, that is basically what I am trying to say here that participating in the labor market and how much labor I will supply in the labor market is an economic decision making. Then consumption is also an economic decision making. What I will consume, how much I will consume, all depends on the price of the product, what is my need, so on and so forth. So, both income and consumption are then generated from economic decision-making because of which both these are economic data. Econometrician will use the income and

consumption data, use the statistical and mathematical tools to analyze that income and consumption data, and check empirically whether increased income actually leads to an increased amount of consumption or not. If not, by how much? So that means, basically in econometrics we will always try to answer the question how much? So, when income increases by 1 unit, let us say by 1 rupee or 10 rupees or 100 rupees, what is the corresponding increase in consumption?

As theory says, when your income increases by 1 rupee, consumption will increase but definitely less than by 1 rupee. So, this is the first example of economic data. Then we will take another example. This is also an interesting example or interesting research question to answer. The question is whether small class size will result in better learning or not. We are concerned about while sending our kids to schools. We see the student-teacher ratio because we believe that smaller the class size better the learning outcome. Now what should be the optimum class size? If the class size is smaller then of course there will be better learning but there is a cost involved. If you want to have smaller class size you have to employ many more teachers, instructors, you need to have more classrooms; you need to have more infrastructure, so on and so forth. So, that means, having a smaller class size involves some amount of cost. Thus class size in that sense is an economic data. It comes from an economic decision making.

The administrator or policymaker will decide about the optimum class size depending on the cost and benefit of a reduction in class size. So, they will see the extra benefit in terms of additional learning that the students are getting and they will try to weigh this extra learning with the extra cost that is involved with the smaller class size. That is why as an econometrician they will take the data on class size measured by number of students and data on learning. You can measure learning outcome, let us say by marks-marks obtained by the students in mathematics or english or any other subject. There are different ways of measuring learning outcome but this is one of the easiest measures. So, then this is also an economic decision making.

Then third example given here is does profitability of a firm determine the returns of its stock? So, stock return and profitability are both coming from economic decision making because profitability, i.e. how much profit a particular firm will generate depend on the output the firm is producing, the advertisement the firm is giving or the R and D expenditure the firm is incurring, so on and so forth. So, that means, profitability is also coming from an

economic decision making. Similarly is the returns to stock. Even if you are profitable you may not be giving much dividends to your shareholders. So it again depends on or who is there in the board and how the firm is valuing the stakeholders. So, both the things are coming from economic decision making. That is why both are economic data and econometrician can analyze the profitability and stock return data to come to a conclusion. Whether actually stock return is related to profitability or not? If yes, then how much for every additional increase in profitability, every additional unit increase in the firms' profit how much does the stock return increases? So, that type of answers also we can get from this econometric analysis. Here all the numbers are 1, 1, 1. But these are the different examples actually.

Then, the other example is whether arranged marriage is more stable than love marriage. Now, getting married itself is an economic decision making. Why? Because economics define marriage as nothing but a mutually beneficial trade or a mutually beneficial contract and stability. Basically whether the marriage contract will be stable or not depend on whether both the parties involved in the contract are mutually benefitted or not. At any point of time, if the benefit of that marriage contract is distributed towards one person, then there is a high chance of breaking up that contract which means divorce. So, we may hypothesize that arranged marriage or love marriage vice versa, whether what type of marriage is more stable. So, that means, the research question that comes to our mind is analysing type of marriage with its stability. Even that analysis can also be done using econometric tool.

Another example is Does a higher economic growth result in improved environmental quality. So, basically, that means, we are interested here to examine the impact of economic growth on environmental quality. There are two ways by which you can think of this relationship. Increased income comes through increased utilization of resources-we will extract more resources, renewable and non-renewable resources from the environment which will lead to degradation of the environment. Secondly, in the process of making growth and output, what we will do? We will also make pollution. There is no output which is produced without making any amount of pollution. You cannot really think of production or any output which does not generate any amount of pollution. Can you think of any activity which does not generate any amount of pollution directly or indirectly?

Even when I am teaching, when I am taking this class, I am generating some amount of pollution indirectly because I am using electricity and how the electricity is generated? By

burning the fossil fuel which itself generates a certain amount of pollution in the environment. So, that means income or production of output will inevitably lead to some amount of pollution making. Then the question is whether the quality of the environment increases as income increases. Why this is so? When per capita income increases, then people become more concerned about the environment. Generally we assume that environment is basically a luxury good. When income increases people give more value towards cleaner environment and they are ready to spend more for environment friendly products. They will also create more pressure on the government to bring in stringent regulation and that stringent regulation will demand the policymakers to ask the industries to take suitable steps so that they can improve the technology that generates output but less amount of pollution. So, that means, we can assume that at the initial stages of growth or production environmental quality will decrease. That means pressure on the environment will increase. But once you achieve a certain level of per capita income, then the pollution may come down.

So, basically, you may think about an inverted U shape relationship between-let us say in the X-axis we are measuring income per capita, and in Y-axis pollution per capita. So you will get an inverted U-shaped relationship. It basically says that once you achieve a certain level of income, let us say this is x^* level of income per capita, then your pollution per capita will come down because of the preference of the public towards cleaner environment and because of the stringent environmental regulation, that government will bring in to cut the pollution.

So now, an econometrician will collect data on pollution per capita, and income per capita. And then, using the statistical tool will analyze that economic data and we will see whether our hypothesis (basically known as environmental Kuznets curve hypothesis) is valid for a particular context or not. Then lastly, Does ban on alcohol lead to lower road accident? So, when you ban alcohol that is an economic decision making. Whether you will ban it or not because banning alcohol involves some loss in government's revenue. So, government will loose that type of revenue by banning alcohol and government will see whether banning alcohol is actually beneficial and if it actually leads to lower road accidents or not. So how we will drive the car on the road is also an economic decision making by the driver. If you run fast, of course, you will reach the destination fast but at the same time there is a cost involved if you drive fast. Then there is a higher probability of making mistakes. That means higher probability of committing accidents as well. So, that means banning alcohol is an economic decision making. The data is coming from the economic decision taken by the

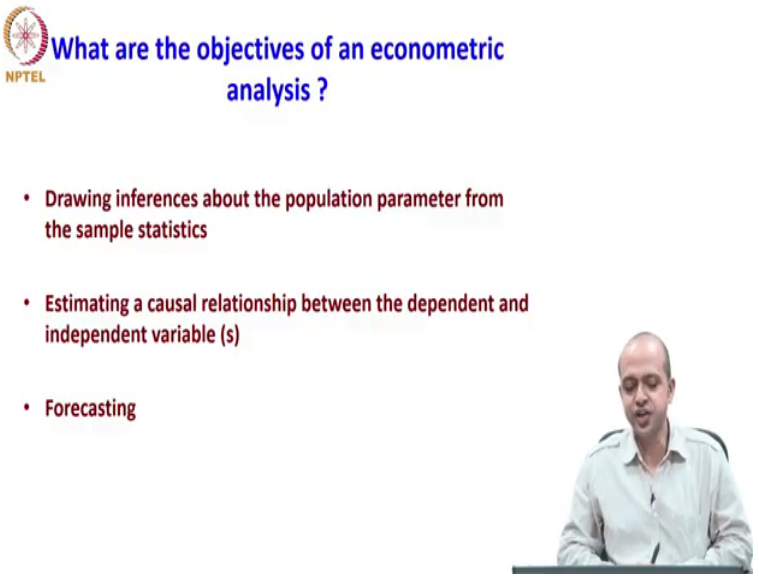
government. And how the drivers drive their vehicle on the road is also an economic decision making from the drivers' point of view.

So, both these are economic datas and econometrician will analyze the number of road accidents pre- and post-banning alcohol or we may also collect road accident data from several states or several districts of a particular state. And all the districts might be having different level of regulation in terms of banning alcohol or not. And then we can analyze the data to come to a conclusion so that we can say whether banning alcohol actually leads to lower level of road accident or not. So, that will help the policymaker to come up with a better regulation.

So, that means the point what I am trying to convey here if we look at all these examples, the have data not only on GDP, money supply, the rate of interest, inflation, and so on and so forth. Generally these are all economic datas, reflecting some type of social problem. They are representing different type of social problems that we would like to answer. So, it is not related to or it is not confined only to a set of particular variables like GDP, rate of interest, inflation, and all.

So that means by now, you should have understood that application of econometrics is much wider and it is not only confined to the domain of macroeconomics like GDP forecasting, forecasting about inflation, how much money supply the central banks should make etc. Rather, you can answer any type of queries that you might have in your mind by applying econometric tools. So, these are all examples of economic data. And this shows how much wider the application of econometrics is in today's world.

(Refer Slide Time: 30:01)



Then the next question that we are trying to answer is the objectives of an econometric analysis. So, there are 3 broad objectives of econometric analysis. Firstly, drawing inferences about the population parameter from the sample statistic.