MINERAL ECONOMICS AND BUSINESS

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Week 3

Lecture 15 : Demand and Supply of Minerals

Hello once again, welcome to this lecture. Our topic today is the demand and supply of minerals, which is a very basic concept that you must have read in classical economics. We will have an applied version of these concepts here—how demand and supply play a role in the mineral market, how we assess the demand, and how we also assess the supply prospects of that mineral. How do they interact, and can we reach an equilibrium through mathematical modeling of demand and supply? Now, in this particular lecture, we will cover concepts like demand analysis. As I said, can we analyze the demand or know the actual demand of the mineral? Can we understand the mineral market scenario through surveys? And what methodology should we adopt, or what options do we have for demand analysis? Analysis of time series data—this is for trend analysis—and analysis based on end use. That means, what the end users are saying and what their prospects are—how they will behave in the future.

If the end-use market induces demand, then from there, we can also find out the rise in demand or estimate the demand. We can, of course, have a microeconomic model for discussing the analysis based on that model, and we will finish with the market survey to understand the demand—the general or traditional method. To start with, we will talk about the demand—the demand for minerals in any country. So, you will see that the demand will, of course, depend on the consumption or per capita consumption. Many materials or minerals in our country, or metals, are consumed much less than in the US or other developed countries.

The demand also changes according to economic growth. And, of course, if the analysis of the demand is well understood, then we can plan how to supply this quantity, which is determined through demand analysis. Demand is basically the primary driver of all these economic activities. The production and consumption of materials, employment opportunities, and exploration also. If you have more demand, you have to explore more and find more resources and reserves for the purpose of auction. Then, you can attract investors, attract foreign direct investment, and create many employment opportunities—all of which depend on the demand, which is the primary driver. What are the factors that affect the demand?

It is the resource availability. Like the minerals as raw materials for the industries. The industries will run based on the resources that are supplied to them. Infrastructure supporting production and processing activities like building construction, road construction, all these things, and many factories and plants. Where in every phase, every case, you need and you understand the role of minerals in that.

So, for infrastructure development, if you have a plan or if you are growing like that, in that case, the demand for minerals will definitely increase or go up. What are the economic variables that will play a role, like export, import, or the substitution trends? We will come to the substitution later. Market dynamics, pricing, and consumer preferences. So, that will, of course, dynamically change the market scenario.

What are the key characteristics of the demand for minerals? Like the elasticity, that means the sensitivity of demand to price changes. If the price changes, do you think that if the price goes high, your demand goes low? Not necessarily. If it goes like that, then the sensitivity has to be understood, and the elasticity of that has to be computed. How is it responding to the price changes?

It may not sometimes it may not. Now multiple uses like mineral like coal that serves diverse purposes. So, the power generation, steel making in the furnace everywhere. So,

it has got multiple use. So, it will have multiple factors to determine the actual demand for the coal and there is substitution effect.

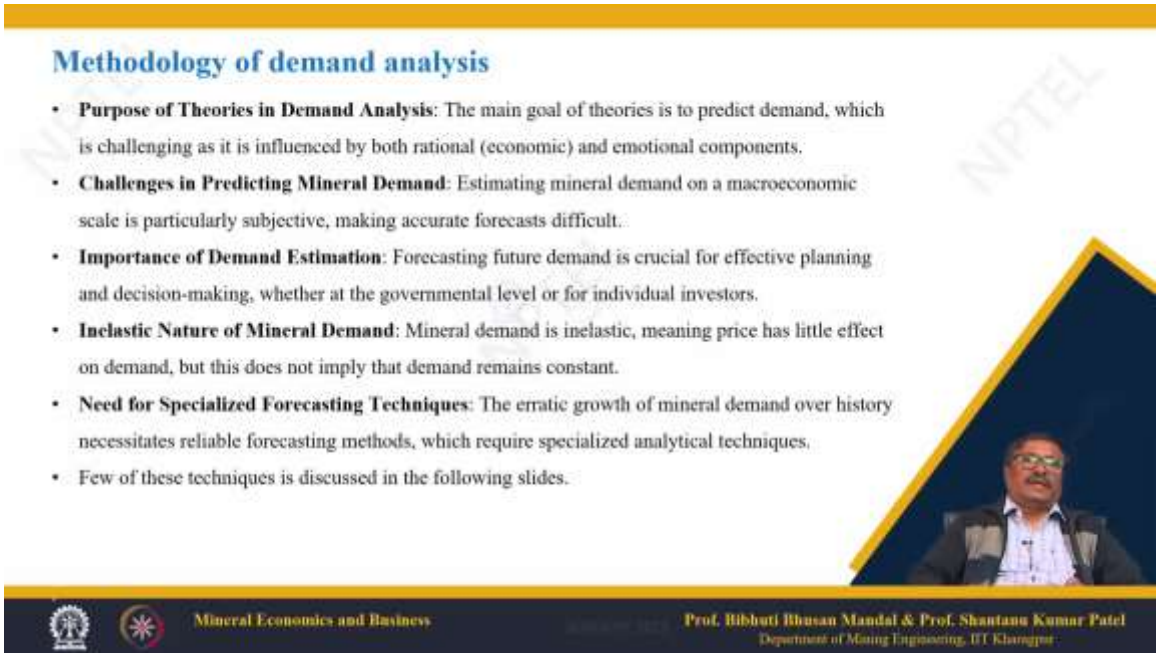
That means, when you are using some minerals or mineral based product and you are coming with a substitute for that and alternative for that then the demand may change. demand may modify. So, in cases where electricity replacing coal in homes. So, there instead of using heating elements or cooking with a gas in that case the demand for coal will drop. So, it is a dynamic market.

So, substitution plays a great role as the technology advances and we find alternatives to replace certain existing or traditional mineral or mineral based product for consumption. The raw materials role the minerals are primarily raw material for industries as we said. So, the demand is focused on the national or global levels rather individual consumption because now it is an open market. So, if there is a market in the other countries then your demand in of production in our country will definitely increase because we have the export opportunity in that. Now, necessity versus luxury that you can live with minimum things also, but you see the number of gadgets nowadays like the washing machines or different heating alloys, the AC many things we are the consumers are purchasing more and more and more.

So, the in case of industry you see these minerals which will produce these items. So, that the demand for those things will grow because from just bare necessity to make it luxury or sometimes you see today what is luxury will luxury will be now treated as a necessity things are changing. So, that will impact the demand ah differently. Multiple uses as you said that coal can serve diverse purposes in one sector within power generation if it increases or decreases not necessarily that in the steel will be directly affected by that. It is a combination of all this demand that will be that will influence the trade market demand ah for the for the coal.

In substitution case as I was telling earlier that if we replace with certain say for example, we are now replacing the vehicles with the electric vehicles, the traditional petrol or diesel vehicles with electric vehicles. So, now the demand for cobalt, nickel, copper material which is required for the electric vehicle will now the the demand will be high. So, in that case also if you are if you are not supplying that that is consistent with the demand then the price may rise for those materials and because those are like lithium that is in high demand now. Technological advancements

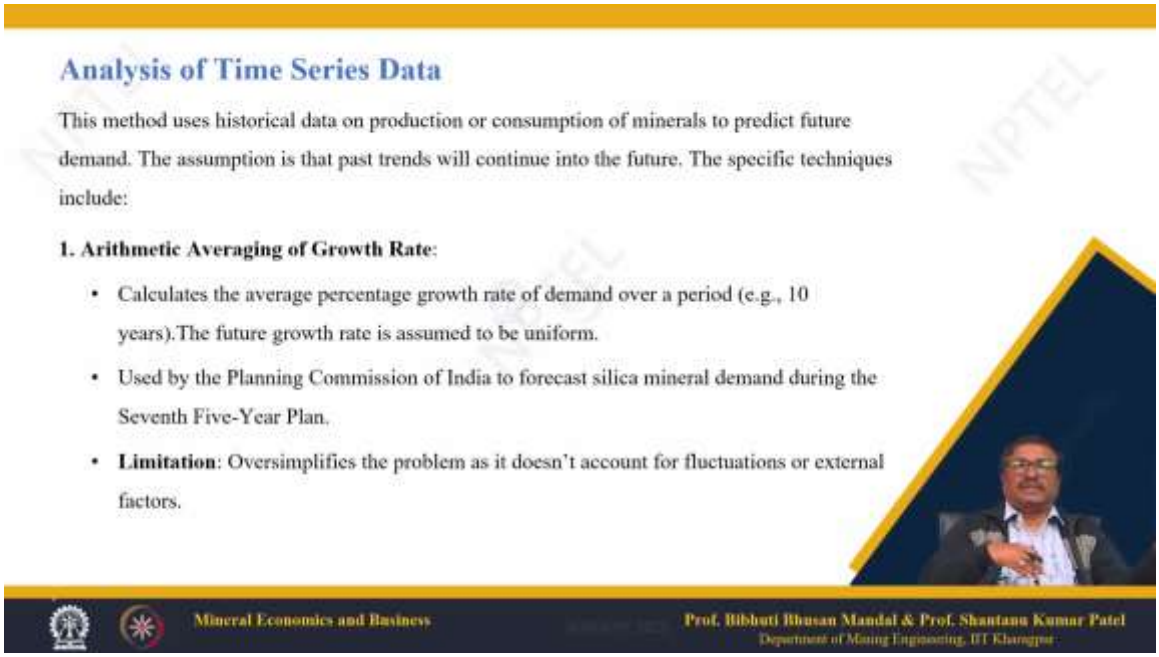
like innovations enable the use of lower grade minerals sometimes we consider the mineral certain low grade mineral as waste. So, what is happening the we are wasting valuable mineral even though it has mineral content value mineral content, but we cannot use it. If the innovative technology comes then what happens then the low grade mineral or something like a waste that becomes a wealth. So, from waste to wealth through technological advances will again allow certain things which were considered waste earlier to come into the market and becomes a saleable commodity in the mineral market. The government regulations or policies rather control mineral prices in coal we have control on that.



And of course, we have a lot of control in average sales price. So, you have to follow the government standards and government rules and regulations, and from there you can find out what the selling prices or the prices of the coal are, depending on which the demand and supply will vary. Now, the methodology of demand analysis is there—why do you require demand analysis? Because we need to know, we need to forecast, depending on which new projects will come. If the demand increases based on some prediction models, then we can come up with new projects, new mines, and new plants.

So, we need to have theories or practices based on that for demand analysis. We have rational models like the economic models or emotional ones like, 'We are going to do

these things—we are going to have the best or the maximum gas-based or coal-based power plants, and we are going to reduce and use more nuclear power.' In that case, both the rational and emotional components—a combination of these things—will influence the We need to have theories to take account of these components. Then the prediction of the mineral demand.



So, on a macroeconomic scale, it is particularly subjective, making accurate forecasts difficult. Sometimes we have certain methods; we know that yes, it is increasing by some method or some averaging method. So, if you focus on something which is not actually the future demand, in that case, we come to or rather, we should use some standard method for forecasting, and the methods nowadays—many methods are emerging due to huge data analysis facilities. The importance of demand estimation lies in forecasting the future demand; this is crucial, and we can do effective planning based on the accuracy of the demand estimation. Now, whether you are an individual investor or the government wants to make policy, that depends on the demand estimation through a rational method.

Now the about the inelastic nature of mineral demand is considered as inelastic in the sense that price has little effect on demand because of the demand in the common market that will not be fully influenced by the price. If the price goes high, it goes high means it does not become skyrocketing prices. So, if slight variation on the upper side will never

affect this thing. So, even if it increases day by day due to any reason including the inflation, the demand remains constant and also it can rise depending on the forecast. Need for the specialized forecasting techniques because if the estimation is wrong in that case the forecasting method if it is wrong then we will have a wrong picture of the future demand.

In that case our planning for the supply production will be also wrong. Some of the method that is traditional and then modern also will be discussed in this lecture. A common thing common method is the analysis of the time series data. You have you have a time series data that a historical data the production or consumption of mineral based on that you can predict you assume that the trend will continue. So, the assumption is that the trends that we have observed in the past will continue in the in the future also.

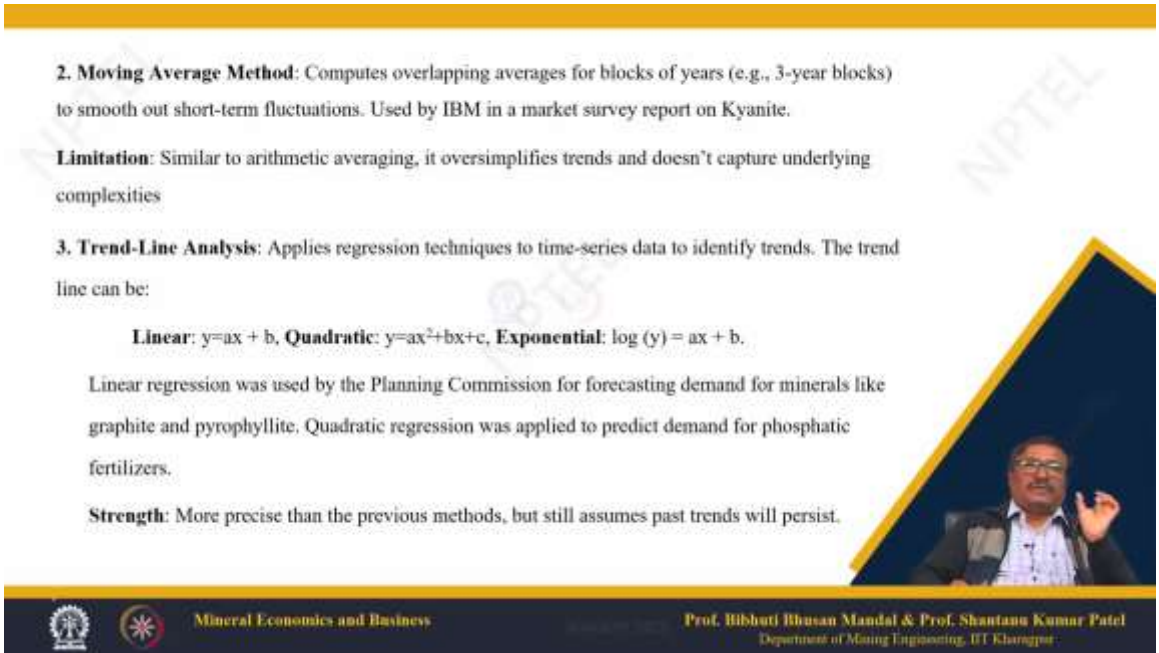
So, the common thing is arithmetic averaging of growth rate. So, when you have data over a period say 10 year period, then take an average and then you forecast that in the coming years also this will be the average consumption from there you can forecast. This is used by say the planning commission to forecast silica mineral demand during the 7th 5 year plan. This is an example does not mean that we are using the same method. So, it oversimplifies the problem because we do not do any other factors we do not consider in this model.

What we do? We just take 10 years data, 15 years data, take an average and find out that in next 5 years this will be our consumption and therefore, this will be our demand in the market. But in the moving average method what will happen? The it computes the overlapping averages for blocks of years for example, 3 years block So, what we do that we take 3 years average and then take 1 for every 3 years.

So, and that will give us average for those small period not over a larger 10 years or 15 years period that will give us wrong figure. Rather this method is slightly better in the same that it smooths out the short term fluctuations in 1 year. some 2 times or 3 times higher for some reason. If you take an average for that period then it smooths out for that period. So, you can find out the trend and it smooths out the short term fluctuations.

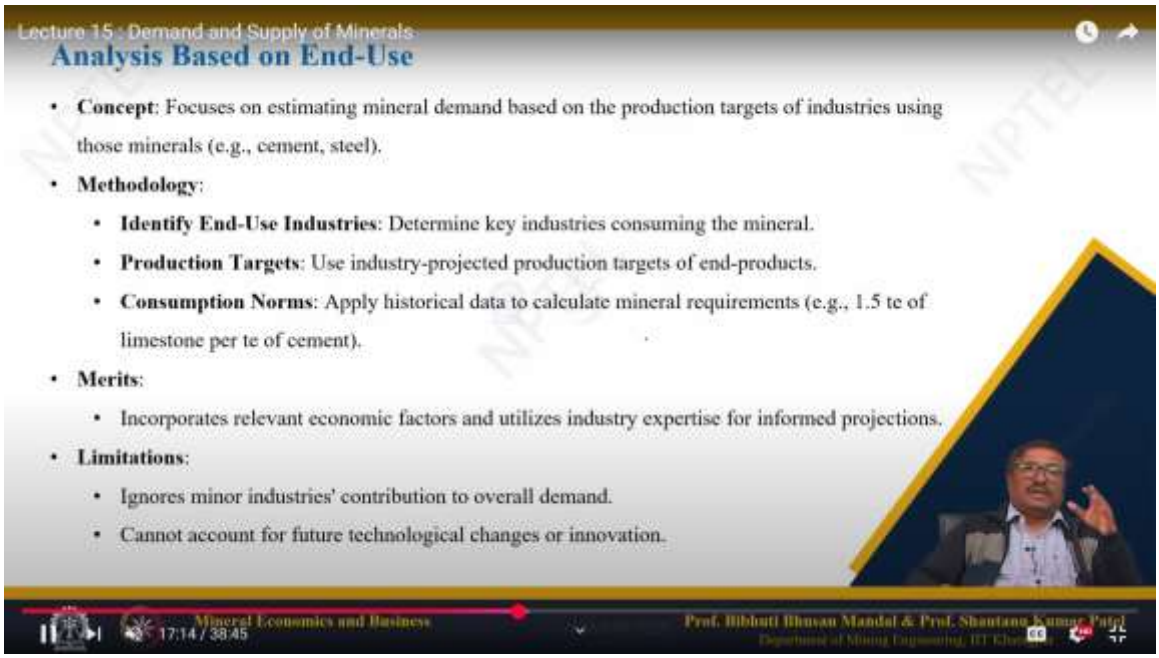
For example, IBM use this technique in a survey report on kyanite demand. So, the limitation in arithmetic averaging is same like the previous one that is tries to oversimplify the trend and does not capture the underlying factors and complexities that could have caused the fluctuation in the demand and supply market. So, what we can do we can find out a trend analysis trend line analysis the minimum thing this applies the well known since you have engineering students you must know these things these are common knowledge for all of you. So, we do the regression techniques apply the regression techniques. to the time series data we have.

The trend line can be a linear one like y equals to a x plus b as you can see here linear or it can be quadratic y equal to a x square plus b x plus c or it can be exponential like log y expressed as a log y equals to a x plus c. So, whichever is fitting into the trend you can use that And when you are getting a good regression coefficient in that case you can you can use this for forecasting for the next 5 years to come or so. So, this linear regression was used by the planning commission for forecasting demand for minerals like graphite for example, pyrophyllite these things or quadratic regression was fitting and it was used to predict the demand for phosphatic fertilizer demand. this is more precise mathematical and better scientific model compared to the previous simplistic method. But it still assumes the past trends will persist because you see whether it is a linear, quadratic or



exponential, it depends on the assumption that the past trends will continue.

The trend is varying fine, but it will continue depending on the variations that we have observed through this models. The models based on end use, which I was talking about in the start of my lecture today. that you can ask the end user instead of doing this survey based on the data that we have rather where this mineral will be used. This demand by the end users should be analyzed is it going to change is it going to change for example, the mineral demand can be estimated based on the production targets of those industries where you are asking the questions and analyzing the demand of those industries which are end users.

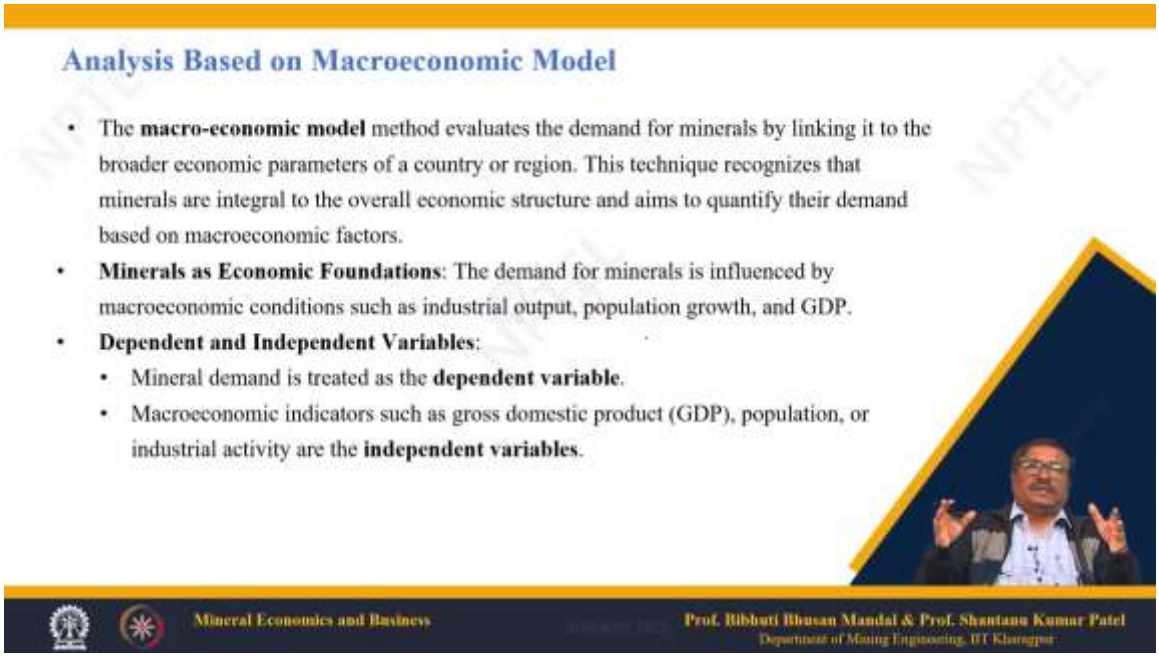


For example, are you going to make more cements? Are you going to produce more cements in the coming 5 years or 10 years? If it is yes, if the answer is yes that means the limestone or the supporting the mineral production has to be increased accordingly. If you have a database based on the end users In that case, you can sum up all those things and come up with an idea that this will be our demand in the coming future.

So, we must identify the end use industries, determine key industries consuming these those minerals and then production targets of those industry by projected production and the end products and from there we can find out the demand and the consumption norms. That means, the historical data to calculate mineral requirement for example, 1.5 ton of per ton of cement. So, from there you can project if you if you need say so many million

tons of cement is required, then from there you can find out what is the limestone requirement from there as I was taking talking about. The merits of this is incorporate it incorporates the relevant economic factors, because it is based on the end use.

So, it is it is basically an informed projection. even if there is no mathematical rigor in this, but it is much more realistic as compared to the other methods that we have said. But finding out the demand of the end use industries is a gigantic task that it requires special expertise or the or the framework to get the information. It ignores minor industries contribution to overall demand and it cannot account for the future technological changes if there is a change in future and the industry has to switch over to that those things are not incorporated in this model that are limitations definitely all models have their scope and limitations. we are talking about now a macroeconomic model.

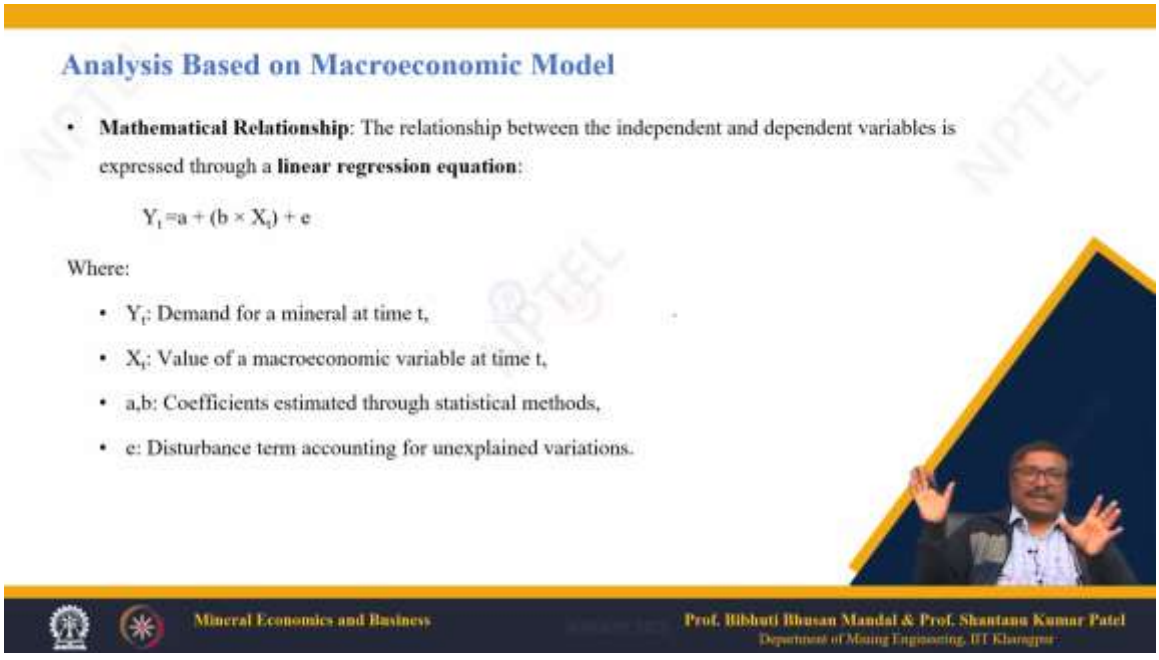


That means, a model that takes into account the macroeconomic features of any economy. So, here this evaluates the demand for minerals by linking it to the broader economic parameters of a country or region. We are actually talking about similar thing which we just now discussed. That means, we wanted to know the end use the demand for the end users all these things.

So, the ah here what we are trying to do it in mathematical terms. So, we are trying to rationalize with quantification much more is better than than as a design of the ah

model it is much better than ah the others. The technique recognizes that the minerals are integral to overall economic structure and aims to quantify their demand based on the macroeconomic factors that is changing. Now the considering the minerals as economic foundation, it is the demand for the minerals is influenced by macroeconomic condition. For example, industrial output, the population growth and then per capita consumption of minerals in our country say and our overall GDP.

because our contribution to the GDP may change and depending on the consumption pattern and also which is again related to the population growth. These are interdependent, but they are major on macroeconomic parameters. Now, for the model we have decided that the dependent and independent variables as follows. The mineral demand here is treated as dependent variable and the macroeconomic indicators such as gross domestic product, GDP, population or industrial activity are the independent variables.

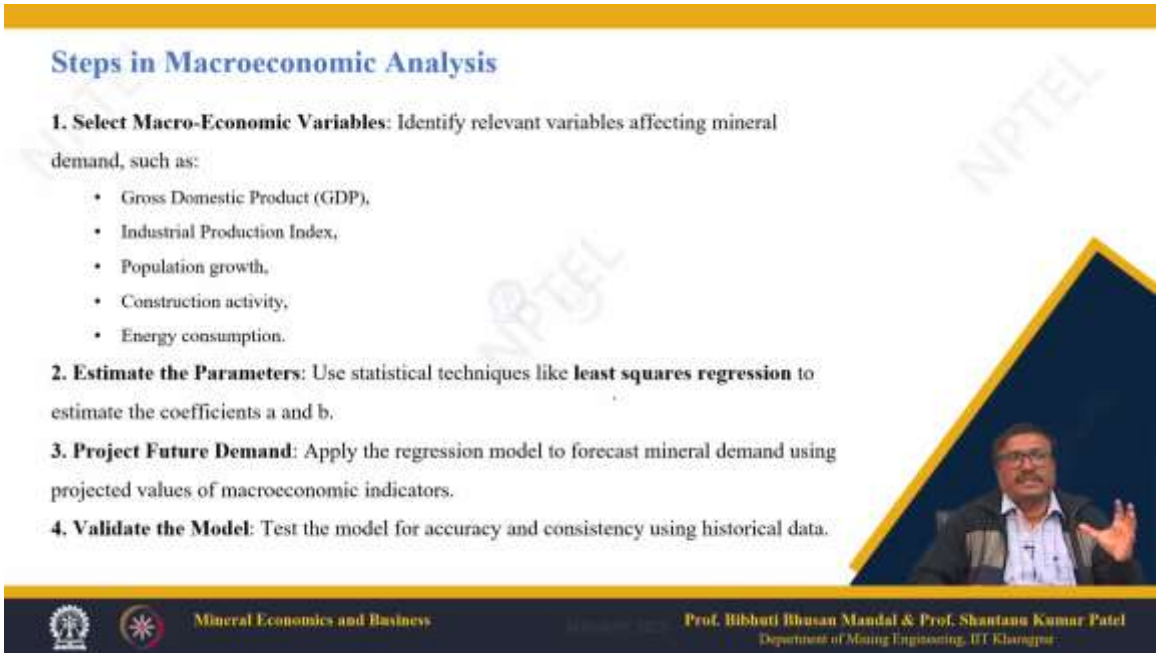


the mineral demand will be treated as a demand dependent variable and the other indicators like GDP etcetera are considered as independent variable. In the mathematical relationship the the relationship between the independent and dependent variable is expressed by say using a linear regression equation. The difference is that the parameters are macroeconomic.

$Y_t = a + (b \times X_t) + e$

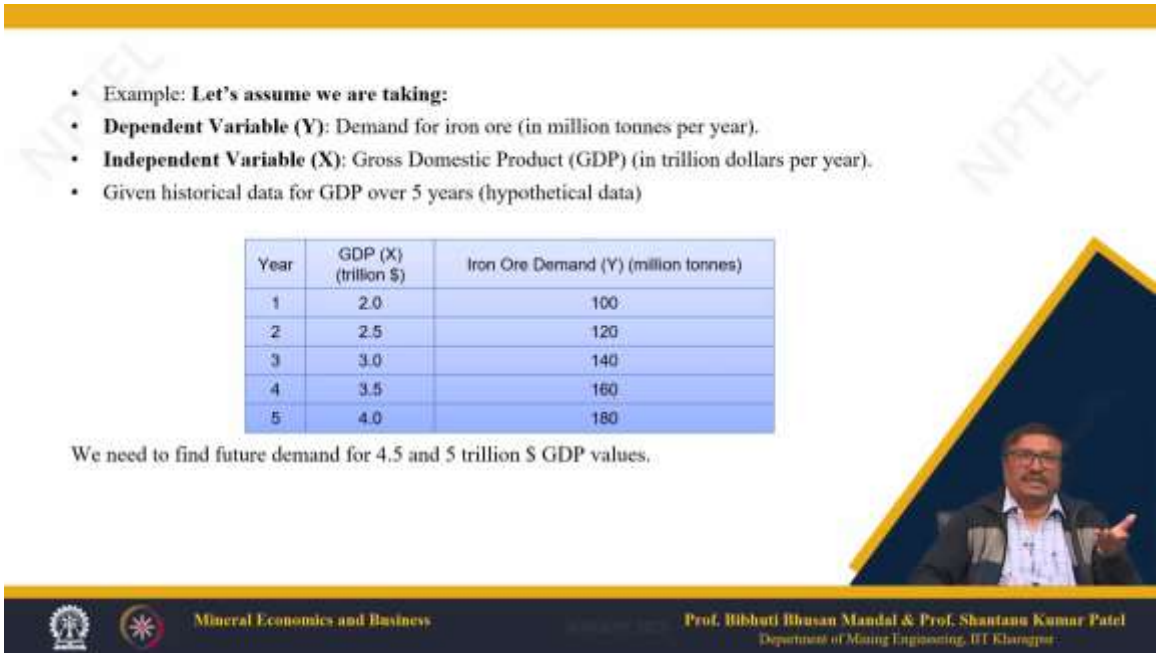
And then, for x_t, it is the value of a macroeconomic variable at time t. The macroeconomic variable we have discussed in the previous slide, and what are these a and b coefficients estimated through statistical methods? We will find out the values of a and b using certain known values we put in the equation, and then first we find out a and b so that in the future, if we want to find out the value of y_t based on a value of x_t, we can do so because we know the values of a, b, and e. E is a disturbance term accounting for the unexplained variations; it can happen. How to select the macroeconomic variables? We can have GDP as one variable, industrial production index, population growth, population.

The construction activity, that means the infrastructure development, energy consumption in a country. How to estimate these parameters? So, we use statistical techniques like least square regression to estimate the coefficients a and b because we need to find out the values of a and b here. So, based on that, we can project the future demand. Apply this regression model when you find out these parameters; then we can forecast the mineral demand using that projected value of the indicators. Then again, we can validate and test the model for accuracy and consistency.



When you develop a model, you can use the data available and then fit it into the equation and test it. Then we can go on refining these things and make it better for use in

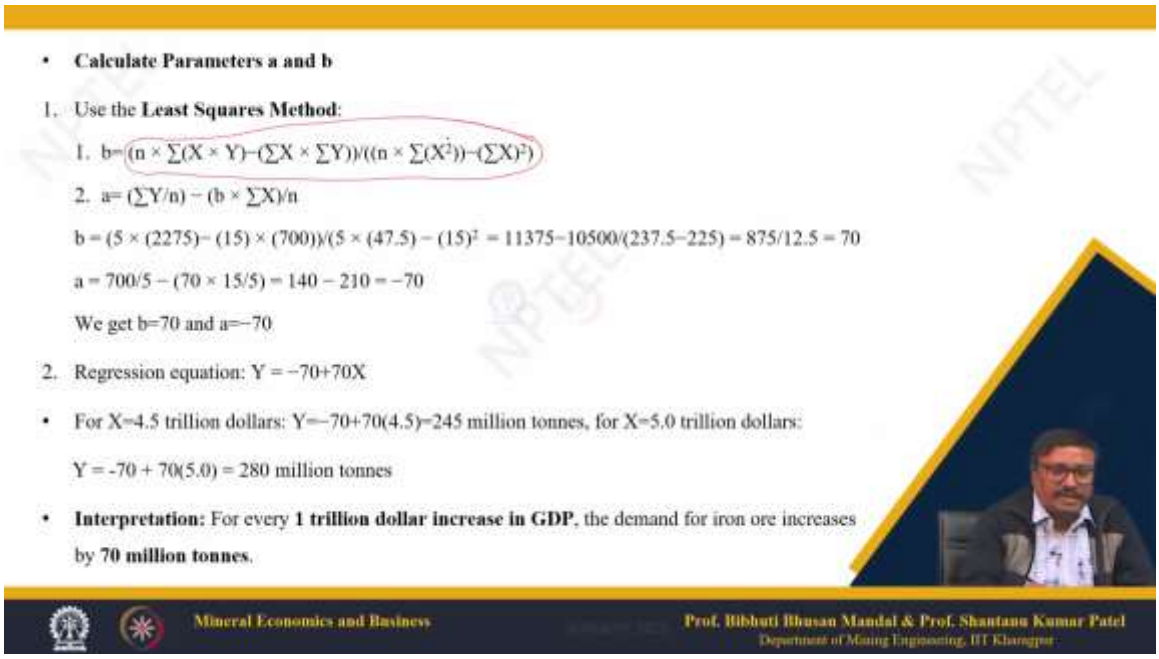
forecasting. Let us assume we take the dependent variable as the demand for iron ore. That means we are doing a demand analysis for iron ore in million terms per year. We are trying to find out the demand for iron ore in million terms per year when the independent variable is the GDP in trillion dollars per year. So, given historical data for GDP for 5 years, say here—hypothetical data here—if we know the GDP values for the last 5 years and if we have the iron ore demand, from there we need to find out the future demand for 4.5 and 5 trillion dollar GDP value.



It cannot always be so linear, as we are increasing GDP, it is not at all linearly related. So, there could be variation; this is a simplistic example. So, from here we can find out the future demand for 4.5 and 5 trillion dollars based on the regression equation that we get. Now, if you use the least square method, which is already known, then from there you can find out the values of a and b here using the collected data. Whatever we have seen, we put the values here and from there we find out that b equals 70.

And similarly, we find out the value of a, which is minus 70 here. So, we now reconstruct the equation with the values that we get. So, we get here, incidentally, it has become y equals minus 70 plus 70x. So, now if you are trying to forecast 4.5 trillion dollars, and

putting these values here, and again for x equal to 5 trillion dollars, then from here also you can find out y equals 280 million tons. Remember that we have used simplistic data for explanation only, for demonstration only; it can vary, and the regression coefficients, the parameters a and b, will definitely not be so simplistic.

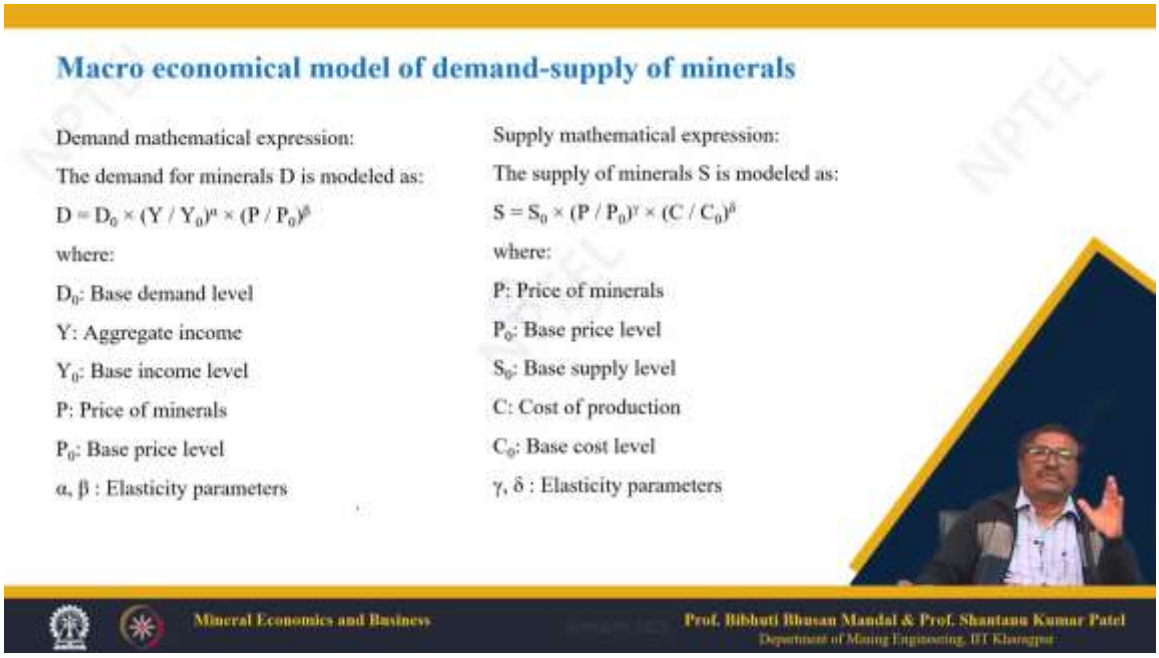


So, if I take this as a model and the values that you compute for the purpose of constructing the equation, then we can interpret this data that for every 1 trillion dollar increase in GDP, the demand for iron ore increases by 70 million tons. So, from there we can find out the interpretation; we can interpret the data like that. So, what are the advantages here? The broader perspective is that it considers the overall economic environment; it is more holistic compared to the methods that depend only on consumption and production. But when you are talking about GDP values, it takes into account the other parameters that influence GDP. So, we are trying to

Connect the GDP with the demand for iron ore. It is a different technique. And it is dynamic in nature, which adapts to changing macroeconomic conditions, ensuring

relevance over a given time. What are the challenges? As I said in the beginning, the macroeconomic variables are also interdependent; they are not exactly independent, not at all.

So, it is challenging to isolate the direct impact of each variable on the demand of that mineral under consideration. And as I said in the equation, the disturbance term—unexplained variations—may reduce the accuracy of the model if it is not minimized through careful selection of variables. That means, unless the e variable is too influential, then the equation will have less meaningful use. In that case, we need to reduce the the disturbance term e as much as possible.



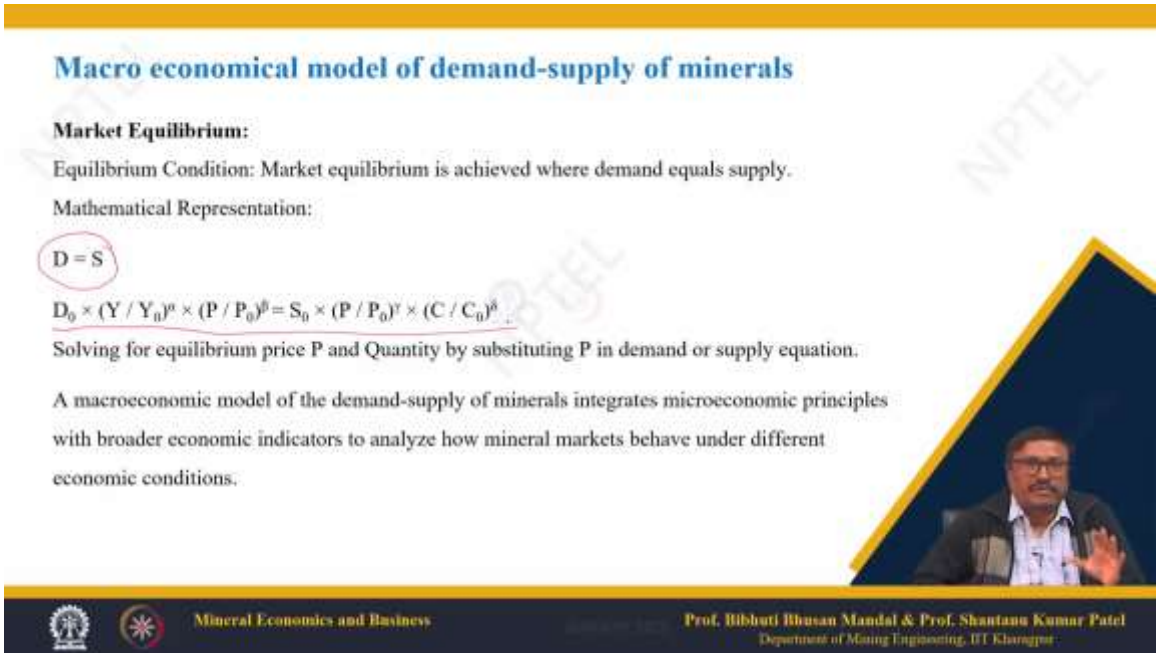
So that the equation more or less depends on the value of a and b, and it becomes a more effective model. Another way of doing it is using a macroeconomic model based on certain publications—these are recent publications. Then we can have a demand mathematical expression and there is a supply mathematical expression here. The demand for mineral D is modeled as :

$$D = D_0 \times (Y / Y_0)^{\alpha} \times (P / P_0)^{\beta}$$

So, where the D 0 is a base demand level and Y is the aggregate income may be for nation and then Y 0 is the base income level. P is the price of minerals, P 0 is the base price level and alpha beta are elasticity parameters alpha beta are elasticity parameters here in this model. Similarly, we have for the supply side for the supply side we have similar mathematical expression. So, supply of mineral S is modeled as:

$$S = S_0 \times (P / P_0)^{\gamma} \times (C / C_0)^{\delta}$$

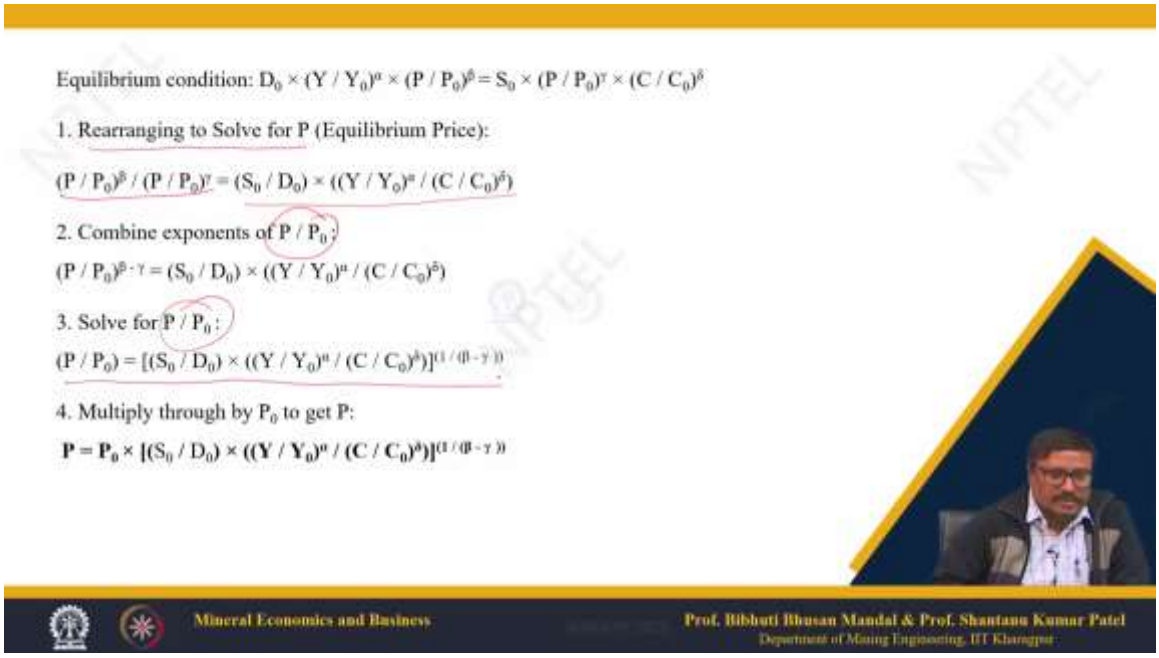
So, the cost C is the cost of production and C0 is the best cost level. So, C by C0 is the ratio here. here gamma and delta is the elasticity parameter elasticity parameter. So, this the equations that you see on the left and the right are looking absolutely similar only the parameters are different for demand and for supply here. For market equilibrium



the demand and supply are to be equal now. The equation for the D and the equation for S are now written in this form. If you solve the for equilibrium price P a price where demand and supply will be equal and quantity by substituting P in demand and supply equation, a macroeconomic model of the demand supply of minerals that will integrate the macroeconomic principles with broader economic indicators. This is basically method for the microeconomic calculations, but using broader term or bigger term bigger variable we are using the same technique here and try to analyze how mineral markets have under behave under different economic conditions.

$$D_0 \times (Y / Y_0)^{\alpha} \times (P / P_0)^{\beta} = S_0 \times (P / P_0)^{\gamma} \times (C / C_0)^{\delta}$$

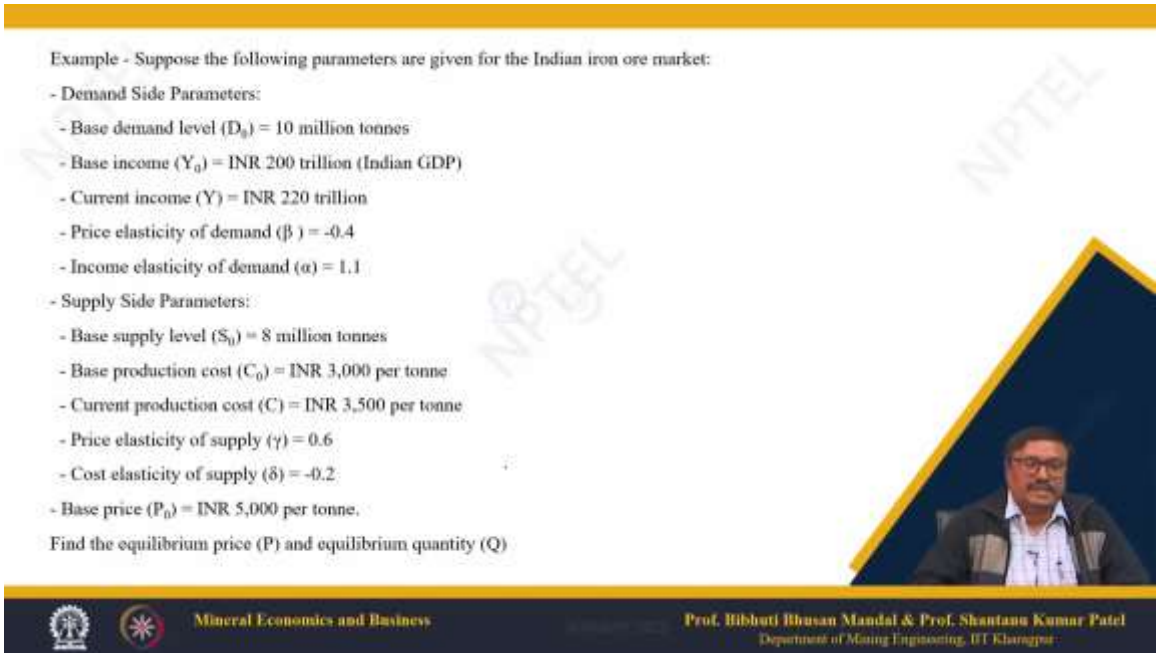
Now in equilibrium conditions, we are now rearranging to solve for P here, rearranging the equation. So, we are bringing the P terms on the left side and the other terms on the right side. We then combine the exponents of P by P0 and we solve for P by P0 here. So, you get this final equation. and then multiply through P 0 to get the P value.



$$P = P_0 \times [(S_0 / D_0) \times ((Y / Y_0)^{\alpha} / (C / C_0)^{\delta})]^{(1 / (\beta - \gamma))}$$

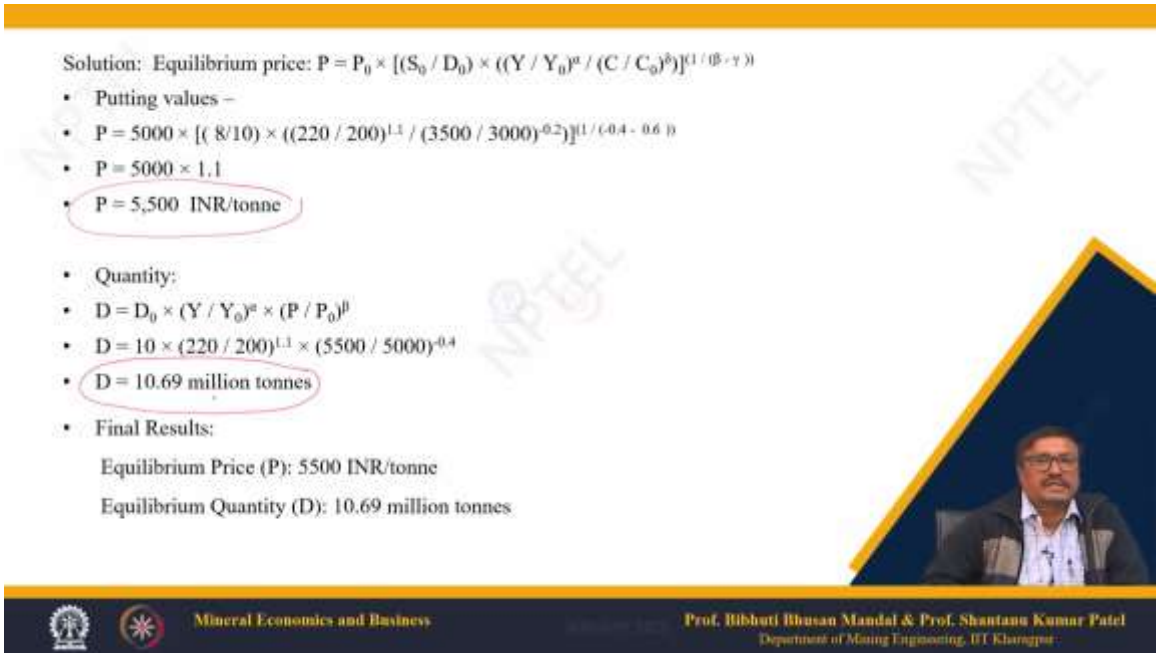
So, here now we have a solution or example or demonstration for the equation that we have found out. Suppose, the following parameters are given for the Indian iron ore market.

So, the demand side parameters the base demand level is say 10 million ton and base income is INR 200 trillion dollars in Indian GDP say and current income is INR 220 trillion. Price elasticity of demand is beta minus 0.4, income elasticity of demand is 1.1. Supply side parameters are say for base supply level it is 8 million tons, base production cost is 3000 per ton assume the changes this will vary depending on the grade also for in this case say we are taking the base production cost as 3000 rupees per ton. Current production cost say has gone up to 3500 per ton and the price elasticity is 0.6 and minus 2 respectively and the base price is rupees INR 5000 per ton. find the equilibrium price P and the equilibrium quantity in this case that could be an example of how what we have developed here.



For the solution purpose the equilibrium price we use the same the equation that we developed after solving for P and we find that the value of P is 5500 rupees per ton and the quantity by solving the same equation we get 10.69 million tons. The final results are for having an equilibrium in the market. The equilibrium price should be 5500 rupees per ton and the quantity to be produced and supplied in the market is 10.69 million tons. So, this is based on macroeconomic parameters, but using the microeconomic models. This is application of that here.

Finding out the values will have separate exercise like the values of the price elasticity parameters that will have separate calculations. From there we will get this value and put this in the larger models. The market survey as I said earlier also apart from the modeling we largely depend on the end users and how people are behaving, how their future demand is going to change. So, for the we has have to be have to develop a systematic process of gathering, recording and analyzing facts about the market for better understanding how the mineral demand will grow or fall, anything.



in the coming year. This process that is why we use in the independent agencies consultant agencies to find out the market demand and that acts as the information acts as as a vital tool for identifying the opportunities and challenges in the years to come. So, when the demand is quite established then the survey process to analyze the critical aspects. For example, reliable sources where from you will get these things and then the product quality standards that we must maintain. We have to plan the production and distribution strategies and understanding the fiscal and economic constant that might affect this operations.

emand plays a central role in market surveys, as I said, as it drives the feasibility of further So, if sufficient demand is identified, businesses can confidently plan their next steps. So, there is no substantial gap between the demand and the supply. However, of course, if the demand is deemed negligible or non-existent, then there will be no need to continue further evaluation, but the most important thing is that it is growing. The demand is growing—the demand for energy consumption, for material consumption, for metal consumption, for mineral consumption—is constantly growing.

Market Survey

- A market survey refers to the systematic process of gathering, recording, and analyzing facts about the market to better understand how goods and services are transferred and sold from producers to consumers.
- This process serves as a vital tool for identifying opportunities and challenges in the market.
- When demand is established, the survey proceeds to analyze other critical aspects, such as identifying reliable sources of supply, assessing product quality standards, planning production and distribution strategies, and understanding fiscal and economic constraints that may affect operations.
- Demand plays a central role in any market survey, as it drives the feasibility of further actions. If sufficient demand is identified, businesses can confidently plan their next steps.
- However, if demand is deemed negligible or non-existent, there may be no need to continue with further evaluations.

So, the market survey is a basic thing that we must continue to have, as we are doing in our country. Every year, we publish it so that investors can understand, and the government can also make an overall plan on how to use this data for the growth of industry and the nation as a whole, where minerals play a great role. So, we can have desk research, and we can have field surveys. So, we have organizations like the Indian Bureau of Mines, which can play a pivotal role in all these things—all the surveys and survey data are available, and the information is also available on their websites. For further understanding, you can read these books or go through the references, which are very important, as we have taken this material from them, and you can increase your knowledge on the subject.

- Methodology:
  - **Desk Research**: Desk research involves studying reports, publications, and available market data to gather secondary information about market conditions and trends. This include analyzing government policies and industry reports to forecast demand and assess market feasibility.
  - **Field Survey**: Field surveys are conducted to collect primary data directly from producers, consumers, and other stakeholders. This method provides first hand insights into market challenges and opportunities.
- Organizations such as **IBM** play a pivotal role in conducting mineral market surveys. These surveys focus on assessing political, social, and cultural factors that influence the market.
- Surveys also take into account consumer preferences, substitution trends, and the prices of related commodities, ensuring that all relevant factors are considered.
- These insights help industries and policymakers to make effective production plans, optimize distribution strategies, and align with market opportunities.

With this, we come to the end of this particular lecture, and we have provided further reading opportunities through which you can increase your knowledge on this topic, which is very important to understand demand and, based on demand analysis, the supply and planning for future production. Thank you very much.