Decision Support System for Managers
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Module - 09
Decision Support System for Distribution Network Design in a Supply Network
Lecture - 42
Transhipment; Flexibility and Six Sigma

Hello and welcome to "Decision Support Systems for Managers"! We are into module 9, 'Decision Support System for Distribution Network Design in a Supply Network' and today's we have two topics for discussion: one is 'Transshipment' and the other is 'Flexibility and Six Sigma'; ok. Now, what happens in the previous lecture, we have discussed about taxation issues in supply chain. And what we have learnt is or it is a basic business, say syndrome or nature.

Anyway it is true for us also that wherever there is less taxation, a company will design the distribution network putting in dots; those countries where there is 0 or very-very less tax; right. I do not want my products in a distribution network to pass through countries that has a very-very high taxation system. Then what will happen? My cost will go up and so, the market price of the product will go up and ultimately I will be out of competition ok. I will be out of the race.

So, no company wants it. So, that is the reason also why almost every country is now striving to have something called special economic zones ok. We had something called export processing zone, then special economic zone ok; so, that is the basic logic ok. So, we learnt that how by using simple techniques companies can redesign their supply chains and go for lesser costs.

And we learnt about product movement from Belgium to France, France to Sweden and then we learnt about the taxation issues in China and US and how companies can circumvent it and re-design their supply chains by taking tax advantage. I would not use the word circumvent, but redesign their supply chains by taking tax advantage, that was phase 1 of supply chain network designing. Today we will do phase 2 that is transshipment and flexibility; ok.

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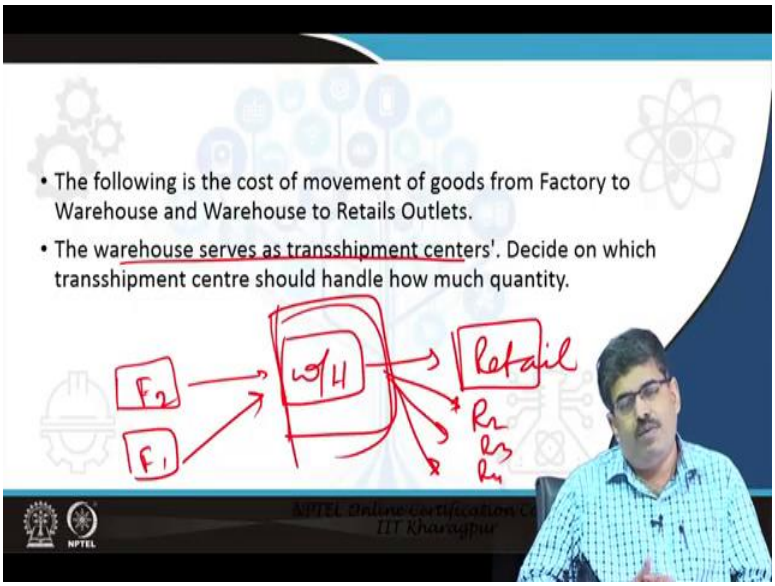

So, the following; so, let us take a problem; ok. The following is the cost of movement of goods from factory to warehouse and warehouse to retail outlets. The warehouses serve as transshipment centers; ok. Now, so, what do you want to say? The following is the so sorry, the following is the cost of movement of goods.

Let us take the first bullet point. The following is the cost of movement of goods from factory to warehouse and warehouse to retail outlets; factory to warehouse and from warehouse to retail outlets; ok. So, following is the movement. Now what it is saying? The warehouse serves as the transshipment centers right. So, what can we say? We can easily say that there are two factories and from warehouses it is going to multiple retailers; ok.

So, what is this warehouse doing? The warehouse is serving as a transshipment center right; actually if you see all warehouses are basically transshipment centers only right. All warehouses are transshipment centers because; what is the function of a warehouse? The warehouse is just providing you some time utility and some space utility; not more than that. Time utility because it has the demand has to synchronize with the supply and so, rather the vice versa the supply has to synchronize with the demand.

So, warehouse is just doing that, it is providing temporary space and allowing for the synchronization of the demand and supply right. So, warehouse is a transshipment

center. Now, the question is how do I model my cost so, that this transshipment system works, right? So, have you understood why warehouse is a transshipment center? Ok.

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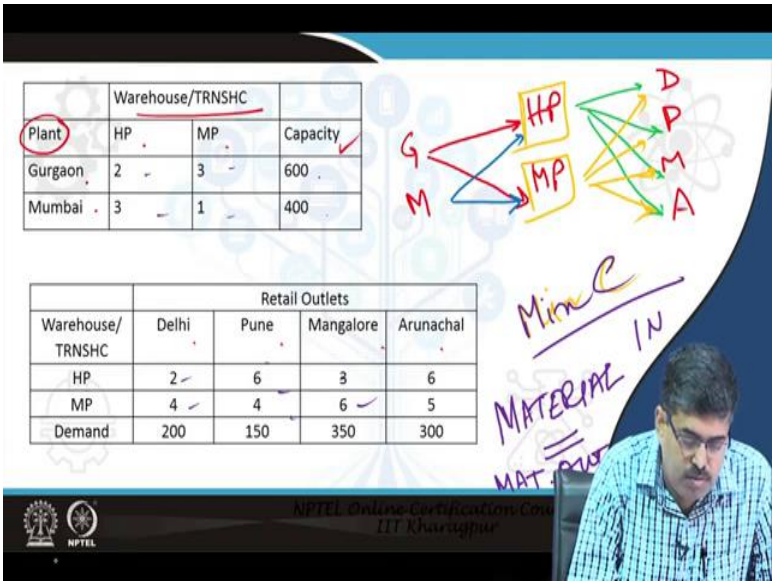

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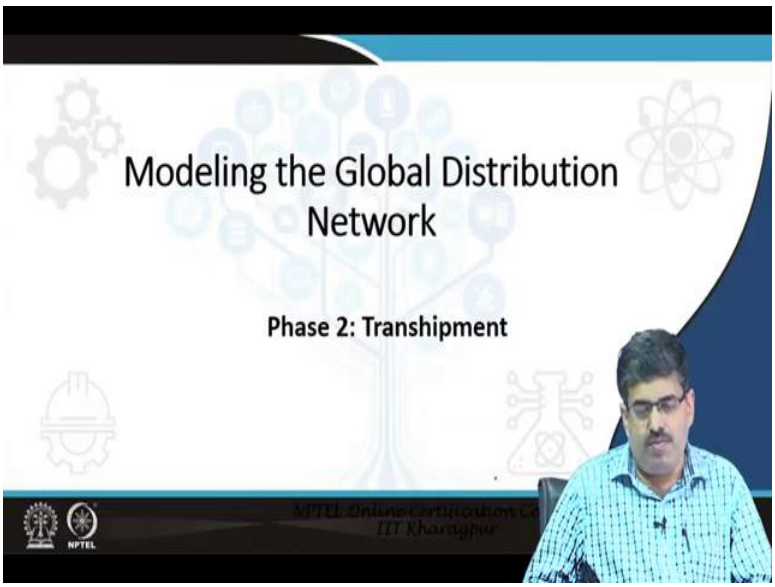

So, first is transshipment; how do you model it? Now, this is the; this was the question; right; the following is the cost of movement of goods from factory to warehouse, and warehouse to retail outlets. And, the warehouse serves as transshipment centers, decide on which transshipment center should handle how much quantity.

So, my factory is in Gurgaon, this is my factory in Gurgaon and Mumbai. And the warehouse come transshipment center at Himachal Pradesh, Madhya Pradesh and these are their capacity; ok. So, let us see and my retail outlets are in Delhi, Pune, Mangalore and Arunachal. So, let us now put it in a drawing. Gurgaon and Mumbai are my plants and my transshipment centers are Himachal Pradesh and Madhya Pradesh.

And my retail outlets are Delhi, Pune, Mangalore and Arunachal right. So, what is happening, what are the options? From Gurgaon it may go to Himachal Pradesh and Madhya Pradesh, from Madhya Pradesh again it can go to Himachal Pradesh. And, sorry from Mumbai it can go to Himachal Pradesh and Madhya Pradesh. Then from Himachal it can go to these places and from Madhya Pradesh, it can go to these places; right.

So, if you see this is the model right, this is the model. What are these? These are my transshipment centers; question is which transshipment center should hold how much quantity? What is the objective or how do we go about it? What should we do? We should look at the minimum cost right, I will use a different color ink; ok. We will use a minimum cost model right and these are my per unit cost and these are the capacity, these are my per unit cost.

Now, essentially you see what does trans; now we let us see if there is an empty space in the next slide ok. Now, let us see. So, now, if you see what my object is; what is it what is the job of a transshipment center? Job of a transshipment center is it is just shift product is coming from here it is giving a space utility and then it is shifting; right.

So, at the end of the day a transshipment center should have nothing, no stock. Now, that end of the day is a colloquial term; it basically means 3 days, 7 days, same day anything. Basically, stock that comes in has to go out; there is no other reason why it should stay in the warehouse; right.

So, at the so, let us let the basic thing at the end of the day; at the end of the day it is something called material in is equal to material out; right. At the end of the day rather I will shift it sorry, I will delete this; sorry; I am so sorry; I will write it here.

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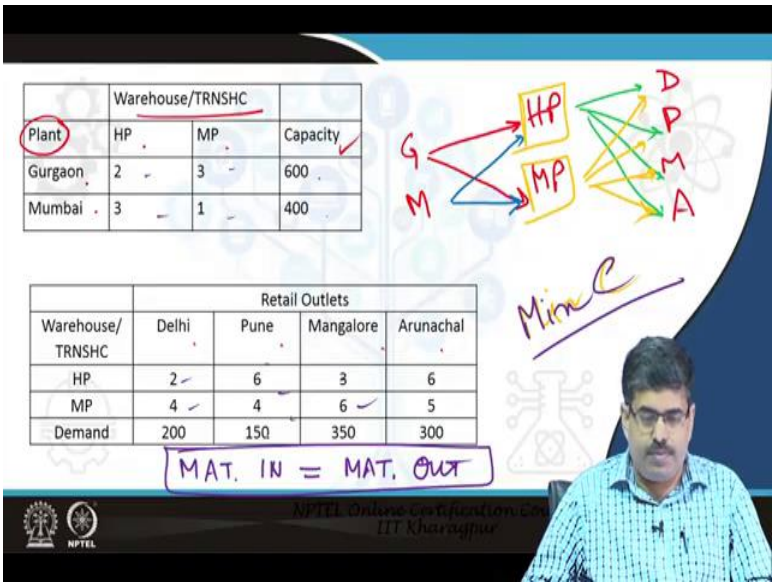

So, at the end of the day all material in the warehouse, here I am writing at the bottom is equal to material out. Theoretically, in a warehouse, there should be no material because warehouse is just a temporary storage of material; right. So, theoretically material in is equal to material out. Now, what is the time frame? Material in, material out, whatever is coming in has to go out; right.

So, what is the time frame? The time frame may be 1 day whatever is coming in 1 day has to go out in 1 day. Time frame may be 2 days; whatever is coming in 2 days has to go out; whatever is coming in today has to go out in 2 days. Time frame maybe 7 days, whatever is coming in today has to go out in 7 days.

But, at the end of the day material in is equal to material out right. So, that is what we wrote. This is the function of a warehouse. In mathematical terms material in is equal to material out is the function of the warehouse.

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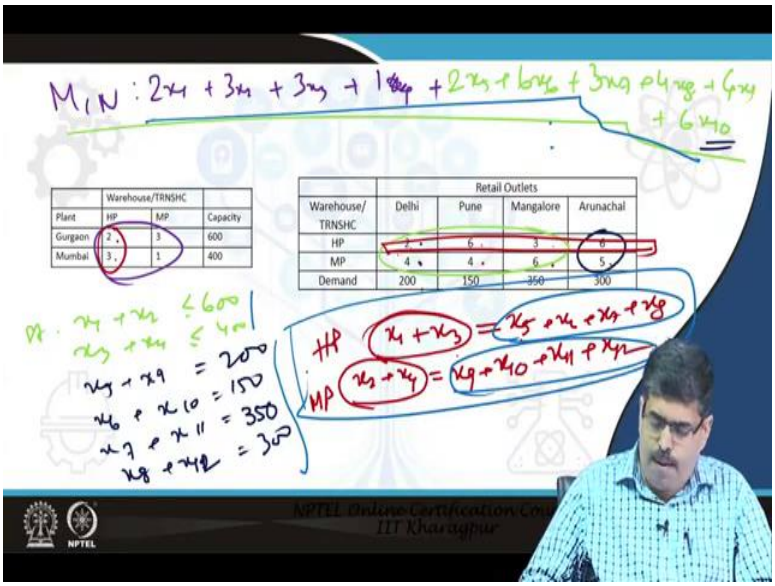

So, let us go how do I how do I model it? Let us model all the costs; the cost is x 1 is the quantity to be moved right. So, first let us do this one; 2x 1 plus 3x 2 plus 3x 3 1 1 x 4. Then let us take this one plus 2x 5 6x 6 3 x 7 4x 8 4x 9 plus 6x 10. This entire cost has to be has to be minimized. So, this is my objective function subject to x 1 plus x 2 x 1 plus x 2 less than equal to 600 x 3 plus x 4 less than equal to 400, because that is supply.

What is the demand? Ok. Demand x 3 x 4 x 5, this is the demand; demand I will use another ink ok. Demand I will use blue, demand is x 6 x 5 say x 8, this one, this plus this is equal to 200 x 6 x 9 150 x 7 x 10; remember our last was x 10 350; I am so sorry. This was the last one sorry x 8 x 5 6 7 8 ok. This should be 9 10.

Because we missed out on that 9 10 11 12 sorry; let me write it down then I will erase ok; 6 9 11 12. So, this is my supply, this is my demand. What is pending? The transshipment material in is equal to material out right. Let us use brick color ok. What is coming in? In the warehouse of Himachal Pradesh what is coming in?

In Himachal Pradesh x 1 x 3; so, x 1 plus x 3 is coming in Himachal Pradesh. What is going out? x 5 x 6 x 7 x 8 ok, agreed in Himachal x 1 plus x 3 is coming. What is going out? 5 6 7 8 ok. In the warehouse of Madhya Pradesh what is coming in? x 2 plus x 4. What is going out? x 9 10 11 and 12; x 9 x 10 x 11 x 12; clear; right.

So, see material that is coming in this warehouse material; this is what? This is Himachal Pradesh and this is Madhya Pradesh. So, material that is coming in the Himachal Pradesh warehouse is equal to material that is going out of Himachal Pradesh warehouse; material that is going out of Himachal Pradesh warehouse. Madhya Pradesh material that is coming in the Madhya Pradesh warehouse is equal to material; that is going out of the Himachal Pradesh warehouse agreed.

So, now, the entire model is fine; demand total cost minimize. Look at the top total cost minimize, recall the transportation cost. My supply constraint this, demand constraint this and all this is the warehouse constraint or the transshipment point constraint. All materials coming in is equal to all materials going out, my modeling is done; clear. So, this is what the transshipment problem is.

If you look at it, now let me tell you if you look at it; entire supply chain is what? Entire supply chain is a transshipment problem ok, clear. So, this is phase 2 of the supply chain network design; phase 1 was transportation, phase 2 is supply chain network design; ok.

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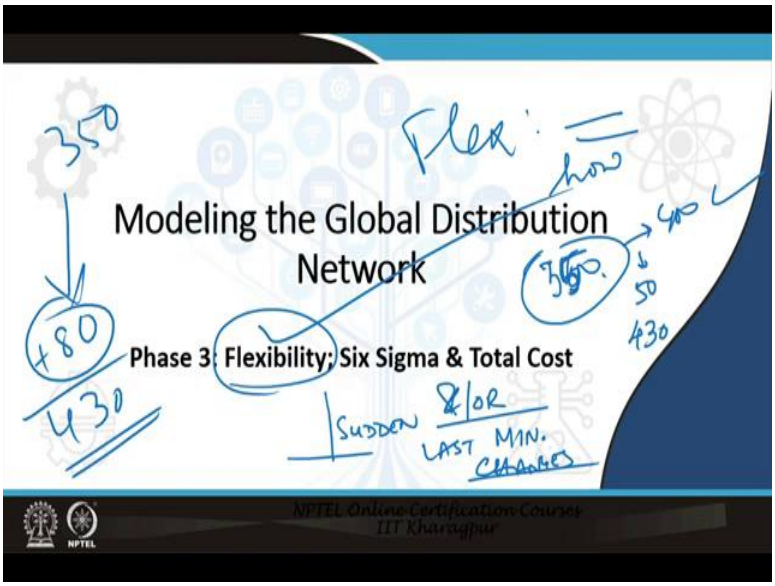

Let us now move to phase 3; ok; that is flexibility, Six Sigma and total cost ok. Now, what is flexibility? Flexibility, basically means your ability to adopt to sudden number 1 and number 2 last minute changes. So, flexibility is your ability to adopt to sudden and or last minute changes right sudden and or last minute changes that is flexibility; ok.

You will see in all our houses, there has been some marriage, marriage ceremony. And there is a food caterer, who takes care of all the food arrangement. What does the caterer want to know from you? How many people have been invited, agreed? The caterer knows from you how many people have been invited, the caterer will tell suppose you tell 400 people are invited; just an example 400.

Caterer will say I will have plenty of food, but how many people's arrangements will the caterer make? The caterer will make arrangements for maybe 350, they will always keep 10 percent less; because some people will not turn up. So, caterer will make arrangements for 350 people. However, and, but they will charge you for 400, but they will make arrangements for 350. However, if actual 400 people turn up then what will happen?

Will the caterer be able to give food, because he has made arrangement only for 350 people? Will the caterer be able to give food? Yes, he will because he has kept some food, uncooked food in stock; the potatoes, the rice and everything is there. He has kept in stock because, if there is a certain rise in the number of people who actually come for that wedding, then he can manage. So, he is not actually cooking it, but he is keeping it there; the uncooked food, the rice, the dal everything; ok.

So, how much is this, that part is called as flexibility. How much is his flexibility? His flexibility equals how many people he can feed, he can provide food for. His plan he was told 400, but he had put he had actually cooked for 350. Now, 400 people have come, what is his flexibility? 50, because he is feeding them; tomorrow 430 people slowly comes and still also he is able to feed; ok.

That means what? His flexibility is he had prepared for 350, his flexibility is another plus 80; so, 430 he can totally feed. So, 80 is his flexibility. So, that is what we mean by flexibility ok. So, that is what we mean by 6 is, let just give me a second; that is what we mean by flexibility.

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Now, what is the importance of flexibility in supply chain? Importance of flexibility in supply chain is suppose you will see suddenly, not suddenly there are, there are two types of importances. One is: there is a planned increase in demand; second is: there is a sudden increase in demand; ok; planned increase, sudden increase. What do you mean by planned increase in demand?

You will see in India before Diwali the demand increases of all types of products, because Diwali is a festive season. In West Bengal Durga puja is the most important season festive festival. So, before Durga puja demand for certain things will definitely rise. What? New clothes, new dress material ok; till some years back painting the house, before the Durga puja; ok. Then what demand? Sometimes people will buy new refrigerator at that time.

So, the units, the business units know that during the Durga puja that is immediately before the Durga puja demand will rise. So, there is a planned increase in demand. Now, take the rest of India; Diwali is a great festival, all companies know that during Diwali people will spend money; that is why you will see huge full page advertisements for of all brands, all companies just before Diwali; ok.

So, that is again a planned increase in demand. Now, when you know that demand will be that and again after Diwali the demand will fall right. So, if you keep on augmenting your system and keep it always at a high to take care of Diwali, Durga puja then that is

not proper; because the rest of the year the demand will not be that high. So, rest of the year the machine will slip, the machine will remain idle.

So, flexibility here this is a planned flexibility, you know that there will be increase in demand. So, you plan yourself accordingly ok. The other is not so, planned flexibility or semi-planned flexibility. This is when Amazon and Flipkart comes with Big Billion Day Sale or something that that Million Dollar Sale or something. So, you know that demand will rise, accordingly you will have to keep things in stock.

You know how to change the prices as and when demand is rising. So, this is very semi-structured; ok. So, that is another way of looking at flexibility ok. Here you have to keep certain products in stock, but somehow you will have to do tremendous demand, supply and price management altogether, all at the same time. So, that that peoples demands are met.

So, that is another aspect of flexibility, the semi-structured aspect of flexibility. The third aspect of flexibility is totally unstructured flexibility, totally unstructured. First one is purely structured; we knew that demand will rise, we know where your demand will rise before Durga puja, before Diwali; semi-structured Big Billion Day Sale or Million Day Sale, whatever is there from Amazon and Flipkart ;ok; semi-structured.

Because we are not sure how the market will react, we know it will react positively, but to what extent we are not sure. If it reacts too much well or in our favor then, we will have to do all the combinations, permutations; the price versus commodity combinations and the demand. Because, if you giving an advertisement there is only 2 units of the product left, but everybody is rushing now; because they do not know how many products you have, but you have only 2 units.

So, that becomes a semi-structured and unstructured problem altogether. So, now, what is a totally unstructured problem? COVID 19, companies never expected that their production, FMCG etcetera will just stop overnight. They will not be able to produce. Mobile phone manufacturers, they never expected that their production will stop overnight. And, they know Amazon, Flipkart never expected that the demand for mobile and demand for laptop will not only rise, will shoot up like a rocket.

Because everyone was working online, everyone was working from home; nobody expected the demand will rise to that level. So, totally unstructured how do you solve; even today COVID 19 started March end. Almost 4 months later still there is the simple mobiles around 7000, 8000 are not available ok. Books, entire new session books there was an anticipated demand and this demand is pretty stable.

Because, up till by now we know that what is the total population of school going kids, how many of them will buy, how many will not buy. Because, the necessary of the authorities are providing them with the necessary books free of cost. And how so, how many will pay, how many will get free; so, you all have this data. So, the demand is pretty much ok, the demand is pretty much simple.

So, we know that, but then suddenly because of COVID all the demand is gone. In the sense, that some schools have purchased the online version of these books. So, all the print copies that demand is now not there. So, those books which have been printed because, April was the session; the new session time April, May, June books are already printed.

But, because the books could not be reached to the intended people, to the students suddenly you need ebooks. So, all the print copies what to do with them? Unstructured; ok; so, flexibility is a great issue; right.

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Examples of flexibility in supply chain, I just shared with you certain examples: structured, unstructured, semi-structured; ok. Even today after 4 months of the onslaught of COVID, there are many items that are not available. And, nobody will be able to say when they will be available.

And these are not necessary goods that without them we will not survive but these are goods that we would buy in ordinary situations; but they are not there; clear; importance of flexibility, yes by the way examples you know what the importance of flexibility is; right.

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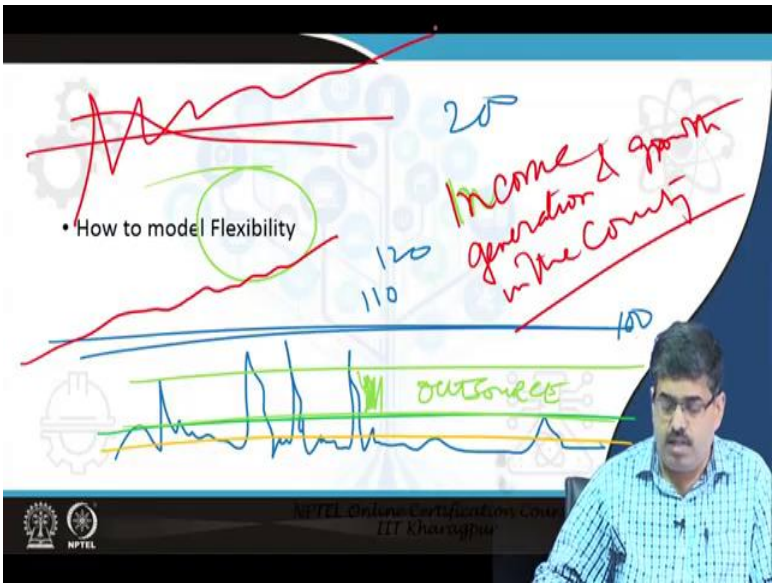

How to model flexibility? Very difficult question; very-very difficult question; how to model flexibility; look at the screen; very important question; very-very important; my demand is this: stable, very-very stable; very stable; so, do I need flexibility? No, my demand is 100; so, how much production capacity machine I will install? 110, max 120; I will not install 200 capacity because my demand is very stable.

But, some product or some system whose nature of demand is very erratic, how much machine capacity do I buy, do I use? Do I buy a machine capacity, do I buy a machine capacity of this much or do I buy a machine capacity of this much? Or, do I buy a machine capacity of this much or do I buy only this much and whenever there is a fluctuation; whenever there is a fluctuation I what? I outsource, whenever there is a fluctuation I outsource.

So, how to model flexibility is a great question and here the answer is not here; answer lies with what? Answer lies with the let me use a different color, answer lies answer lies with the income generation and growth in the country. If the income is not getting generated, if there is no economic growth then you know these types of aberrations will not be there.

Income is increasing we can predict that my demand will also increase or income has to be increase in that same pattern. My income is falling or income is stable, my demand will not shoot up like a meteor right; not possible. So, how to model flexibility that is the answer.

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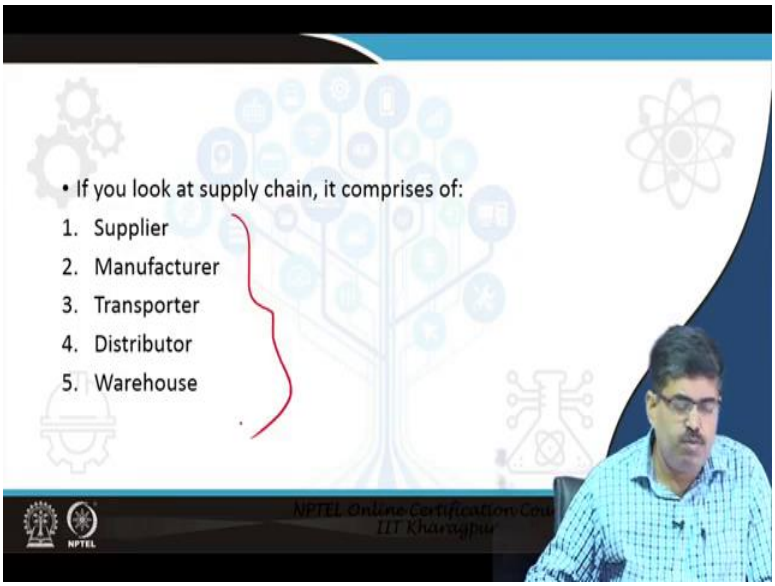

If you look at supply chain, it comprises of supplier, manufacturer, transporter, distributor, warehouses.

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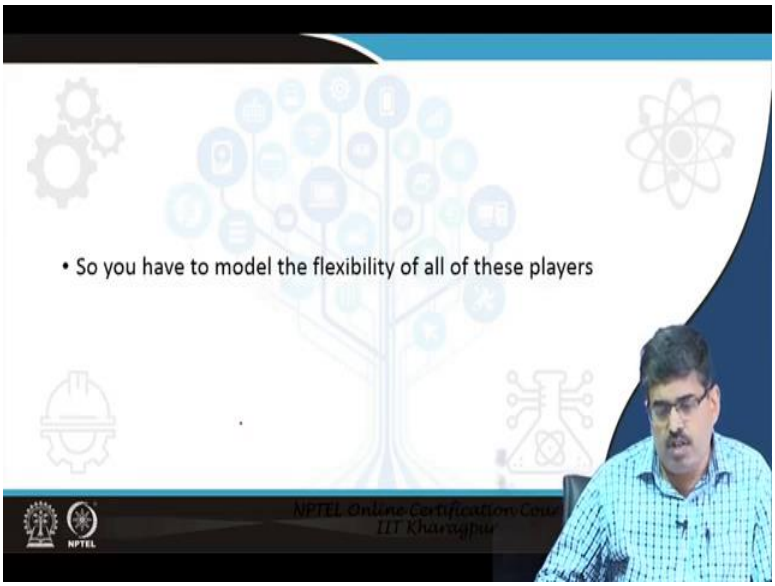

So, you have to model the flexibility of all these players, as I was just saying; ok.

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Now, comes in: associated with flexibility, the concept of Six Sigma; ok.

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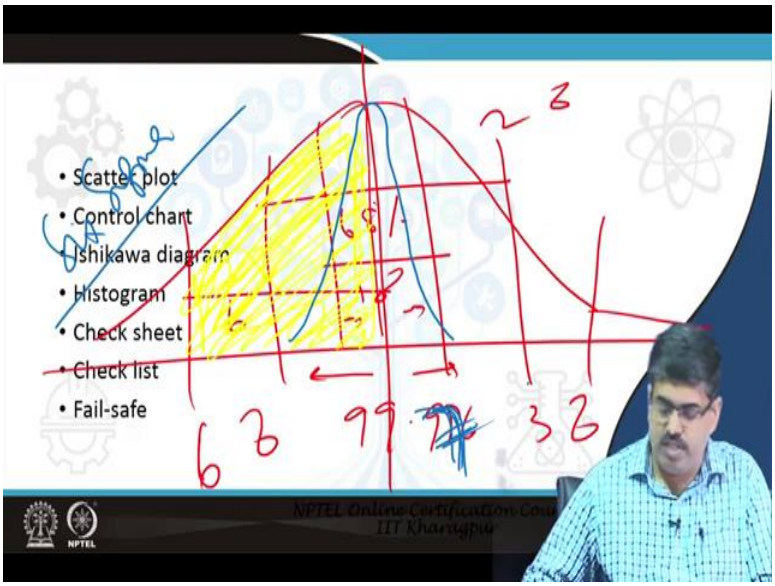

What is Six Sigma? Ok; 68 percent within 1 standard deviation, 95 something within 2 standard deviation and 99 within 99.996 within something within 3 standard deviation on both sides; on both sides, one is on both sides, ok. What now we are saying? We are saying this side is not 3 sigma, this side is 6 sigma.

So, what is happening? This entire thing you are dividing it by instead of 3 divide by 6. So, what is happening? If your entire thing instead of dividing by 3, this entire thing instead of the center; sorry, let me use a different color. If this entire block, if this entire block instead of 3 we are dividing by what? We are dividing by 6; right.

So, what will happen? If this entire thing we are instead of 3, we are dividing by 6 what will happen? My variation will be reduced, that is what is Six Sigma ok; that is what is Six Sigma agreed. So, what is happening? What are the tools? Scatter plot, control chart, Ishikawa, histogram, check sheet, checklist, fail safe technologies; yes.

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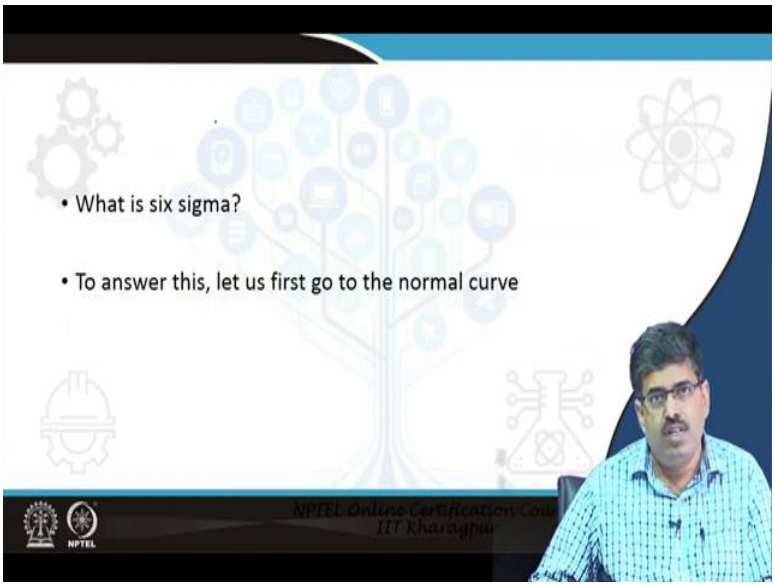

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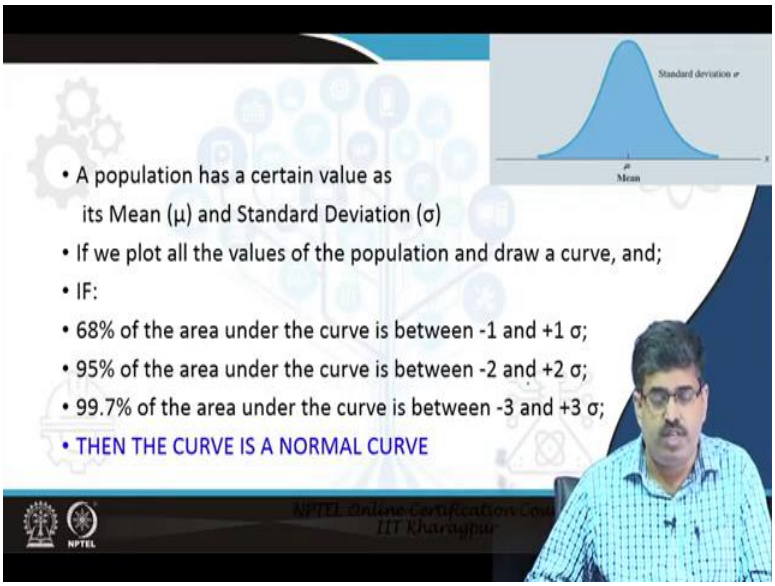

Let us first go to the normal curve, we have already gone ok; 68, 95, 99.7; I put it 99 point no 99.7; sorry, 99.7; ok. Then the curve is normal curve; ok; this just go through it. Just pause your computer or mobile and just go through it; self-explanatory; ok.

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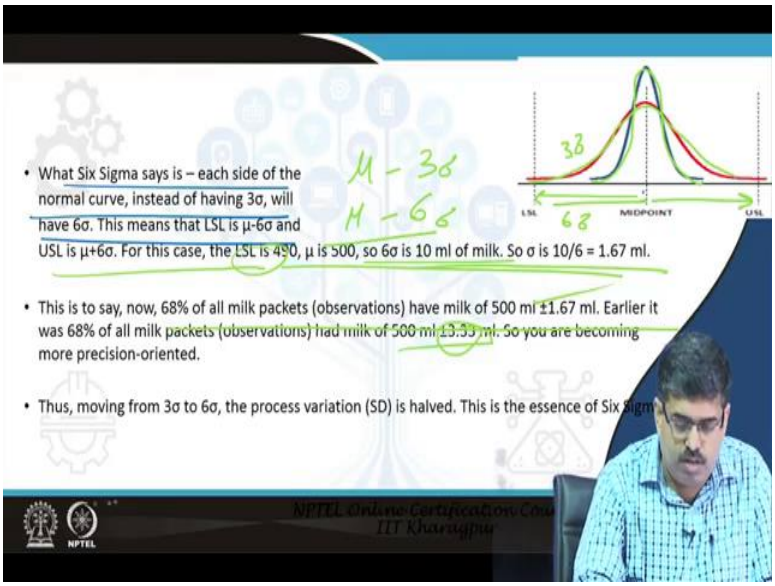

What Six Sigma says is each side of the normal curve, instead of having 3 standard deviation will have 6 standard deviation. That means, that the lower specification limit that is between mean and this value, that is between the mean and the LSL mid mean and the USL is now not mu minus 3 sigma. It is now mu minus 6 standard deviation; ok.

This entire thing is now what? 6 standard deviation, earlier it was what? 3 standard deviation, this was my 3 standard deviation. This is my 6 standard deviation because you are now dividing it by 6 instead of 3. So, you are reducing the curve by half in that sense, you are making the curve thinner. I am not going into the statistical part, you are making the curve thinner by half; that is to stay if you are taking a now USL.

So, for this; so, take the example of the milk, LSL is 490; there is a milk example here LSL is 490 and so, 6 sigma is 10 millimeters, 10 milliliter of milk. So, 68 percent of all milk has a 1.67 ml of variation, standard deviation. Earlier it was 68 percent of milk has 3.33 sorry; I will just remove the eraser 3.33 ml ok. So, that is halved, that is moving from 3 to 6 sigma, the process variation is halved. This is the essence of Six Sigma; ok.

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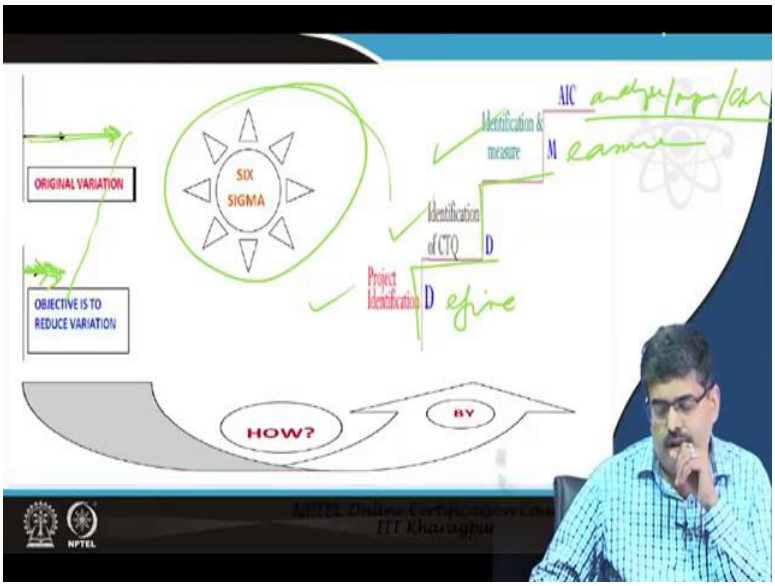

So, what is Six Sigma basically? It is the original value, original deviation; objective is to reduce this deviation to little bit, objective is to reduce this deviation to a great extent. How? So, original variation is this: objective is to reduce this variation to a great extent; reduce it; ok.

How? Through a process of define, measure, analyze, improve and control; define, measure, analyze, improve and control ok. So, this entire thing is called as Six Sigma ok. How do you do this? Project identification, identification of the critical to quality, identification and measure; and once you are able to do this; you are pretty much set to implement Six Sigma.

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These are the references again: Design and Managing the Supply Chain; Simchi-Levi, etc. So, I think this; so, what we have done till now? At the first phase of designing the supply chain, we learned: tax is very important. I will use a different color ink; first phase we learned that tax is very important.

So, first phase we learned that taxation is very important. Next we did that; once we are done with tax, we will have to do transshipment problem. And then we learned that it is very important to have flexibility in the design; and when we are doing this, we are also looking at flexibility; means you will have to look at Six Sigma also; ok. So, we have covered up to 3 phases of supply chain description and design; taxation, transshipment, flexibility, and Six Sigma; ok.

So, in the next lecture, we will come up with the next phase of supply chain design.

Thank you!