Modelling and Analytics for Supply Chain Management

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Lecture 53

Six Sigma and Queuing in Coordination

Hello and welcome to Modelling and Analytics in Supply Chain. As you know, today is week 10 and we are in Coordination Modelling in Supply Chain. We gave you the exposure on coordination modelling in supply chain over the last 2 weeks or over the last 2 lectures, rather and there, what you learnt is that coordination is the most important element in supply chain. Because as we all know that supply chain as such, is basically an activity that takes your product from place A to place B in a timely manner.

Now what is timely manner? Timely manner basically means that the product has to reach on time on time. On time, what does it mean? What is the importance of the word or meaning of the word 'On Time'? 'On time' means neither before nor after. If your product reaches before, what will happen? You will have to store it and we are not talking about one single unit of a product, we are talking about may be 20, 30, 40 truck loads of raw materials. We are talking about 20, 30, 40, even 100 truckloads of finished product.

You have seen, all of you have seen railway wagons moving along the railway tracks. Imagine 70 to 110 wagons moving. So, that much we are talking about. So, if your product reaches before, you will have to store them. Your vehicles get stranded. You will have pay money, pay money to the drivers and the helpers for the standing vehicles. So, reaching before means additional cost. Similarly, reaching late also means additional cost, because your production is delayed.

So, on time, the word 'On time' becomes very very important in supply chain modelling and all of you have heard about a term called OTIF, On Time In Full. This is also very, very important, not only on time, but it should be as per your order. Whatever you have ordered, the product should count and in terms the quality be the same.

So, that is basically coordination on time. So, if your product reaches on time or has to reach on time, coordination becomes very very important. So, your supply chain, basically, the coordination is the center, coordination is the center, based on which your entire supply chain is revolving.

Now so, here, the first thing that we learned in coordination, in the previous two lectures was that, if there is information distortion, then your entire coordination system will go haywire. I do not share information. The other party does not share information. Another party does not share information.

So, if people do not share the correct information, the coordination system goes haywire. That gives rise to your entire ERP systems. That gives rise to your entire computer networks. That gives rise to your barcoding. That gives rise to your RFID. So that you can gather real time information and the possibility of information distortion is wiped out.

So, the first step to coordination is taking care of information distortions and this we learned showing you the bullwhip effect and as part of modeling and measuring, we learned how bullwhip effect has to be measured. As a recollection, it is a standard deviation of the next step divided by the standard deviation at the present step. The next aspect that we have started with, in the previous lecture is the Six Sigma Approach to Coordination.

This is a pretty new thing. Six Sigma in bits and pieces were there many places. But six sigma approach to coordination is the mathematical way to bring in a robust and a very very efficient coordination system. Now, if you see, six sigma was, what is basically six sigma?

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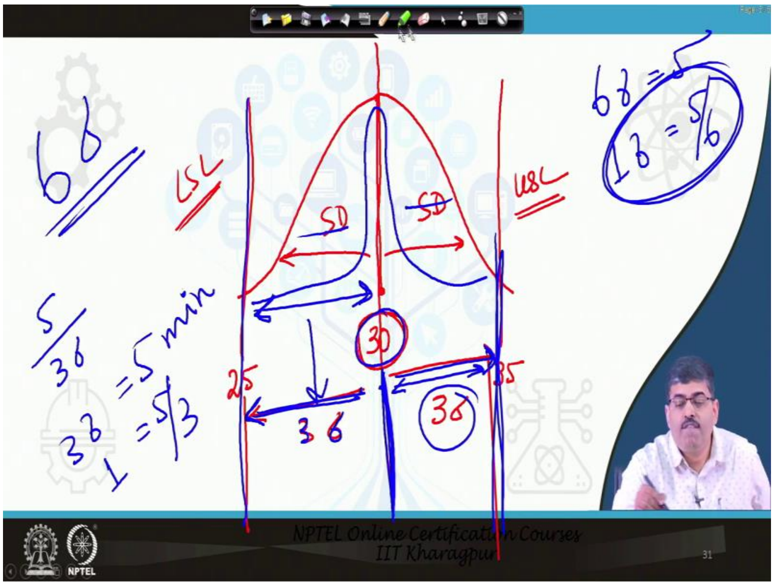

Just as a recap, if you can see, six sigma is basically, I want a system that will perform with this average time, with this average time. That means my activity should be completed, let us say in 30 minutes. Let us take an example, let us take the warehouse example. A truck is coming, a vehicle is coming.

Entire loading and unloading has to be finished in 30 minutes. So, that is the average time. Now because humans are involved, these 30 minutes in some cases can be a bit more and in some cases, it will be a bit slightly less. This is basically the deviation from the average or my expected time of 30 minutes. This is the deviation and if you are going back to statistics, we can take this as the standard deviation. Now, if you can again go back to statistics, this is the upper specification limit and this is the lower specification limit.

That means these are the boundaries that we have set. Just a repetition, my truck. What is this? Again we are explaining, my truck is supposed to complete loading and unloading. My vehicle is supposed to complete loading and unloading in 30 minutes and we are saying ke okay, 35 minutes is also fine and we have seen from previous experience, that some trucks finish loading and unloading in 25 minutes also. So, 35 minutes is also fine as the upper specification limit and some trucks finish within 25 minutes. That is the lower specification limit.

Means no truck normally can finish in less than 25 minutes. So, that is the lower specification limit. So, and this is the average. As we have just mentioned, 30 minutes is the average. So, this side is, if it is a normal curve. So, this side is basically, this side is basically your 3 standard deviation and again, this side is basically another 3 standard deviation. As per principles of normal curve, the difference between the mean and the upper specification limit, this is 3 standard deviation.

As per specification, as per the properties of the normal curve, the difference between the mean and the lower specification limit, again is 3 standard deviation. So, what we are saying is, this is 3 and 3, this is 3, this is 3. What six sigma is telling is, that this difference between the, between the mean and the lower specification limit, this is no more 3 standard deviation. This is 6 standard deviation. That means, what was the difference? My average time taken for loading-unloading was 30 minutes and I can finish it off in 25 minutes or I can finish it off in 35 minutes.

So, my 5 minutes, my 5 minutes is my 3 standard deviation. My 5 minutes is 3 standard deviation; 3. My 5 minutes is 3 standard deviation. 30 and 35, 30-25. What we are saying is, 5 is 3 standard deviation. So, what we are saying is 3 standard deviation is equal to 5 minutes. So, what will 1 standard deviation be 5 by 3. So, roughly 1.66. Now, what we are saying is this 5 minutes, these 5 minutes, these 5 minutes is now 6 standard deviation. So, 6 standard deviation is 5 minutes.

So, what is 1 standard deviation? That is 5 by 6. So, standard deviation is much much less. So, that is the objective actually, of any company to remove the, standard deviation is much much less. That is the objective; to reduce the standard deviation, to remove the variability. Now, imagine, if all the elements and processes in supply chain, if all the elements and processes in supply chain follow this type of a reduced standard deviation. Then my variability is coming down. Earlier, this was the variability.

Now only, now only this much is the variability. So, if every place, variability is coming down, I am able to very very well project, how much time a process will take and so there will be no or very little gap among processes and so coordination will become very very easy. So, six sigma is a way, by which you can implement coordination very very effectively. This is what we have actually, this is what we have actually spoken about.

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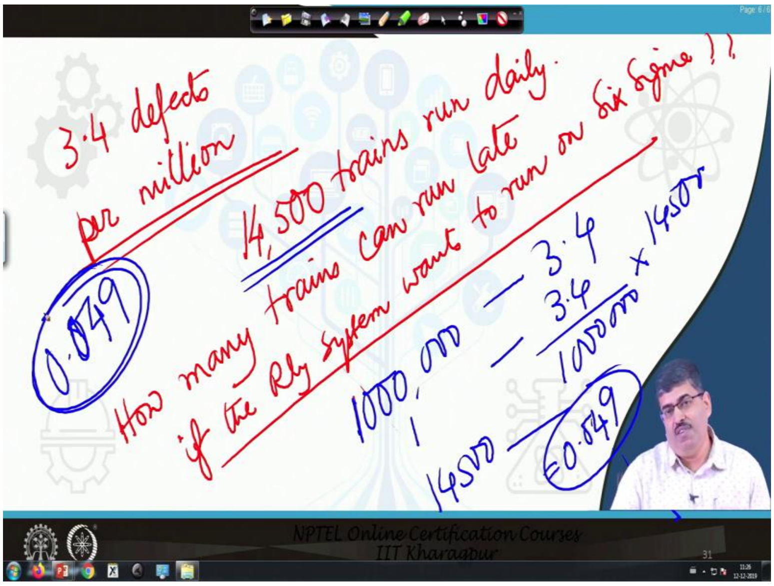

Now, let us take an example. What is six sigma? Six sigma is basically what, 3, six sigma means what 3.4 defects per million. Now, I will give you small example. In India, assume 14500 trains, 14500 trains run daily. How many trains can run late, if the railway system, if the railway system, if the railway system wants to run on six sigma. 14500 trains run daily. How many trains can run late, if the railway system wants to run on six sigma? What is the solution?

In 1 million, in 1 million, 3.4 defects are allowed. That means 3.4 late trains are allowed. So, in 1, 3.4 divided by 1 million and so, in 14500 trains, 3.4 1 million into 14500, 14500. So, now you can easily calculate and the answer I think, will come in to somewhere, something like 0.046, something, something, something like that. Answer will come in something like that. Anyway, but we will calculate the answer. Just, just give me a second; I will calculate it and tell it to you, 0.0493, 0.049. So see, 0.049 trains can run late, per day, allowable if Indian Railways want to achieve six sigma.

Out of 14, 500 trains, even less than half, half even less than, that is 0.05, 0.05 trains, not percentage; 0.05 trains can run late, if your system wants to run at six sigma. So, this is, so now imagine a supply chain, with so many vehicles moving from the factory, so many vehicles coming in from different destinations, so many workers, so many production units, everything.

So, now you imagine; how many chances of defects are there and how many defects you are allowed to make your system full proof and only when you can make your system full proof, then only you can have a efficient effective coordination. So, six sigma plays a very very important role in determining how well you are placed in coordination and what you can do, what you need to do, how much changes you need to make, to achieve the desired level of coordination.

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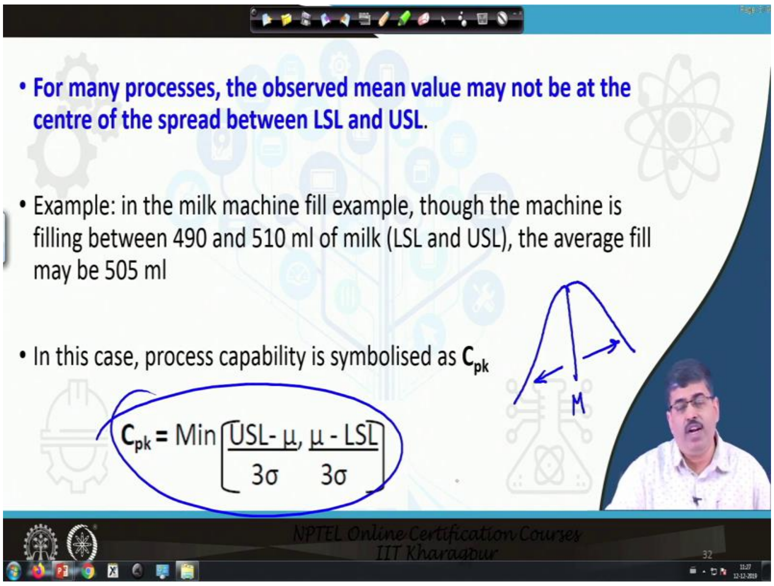

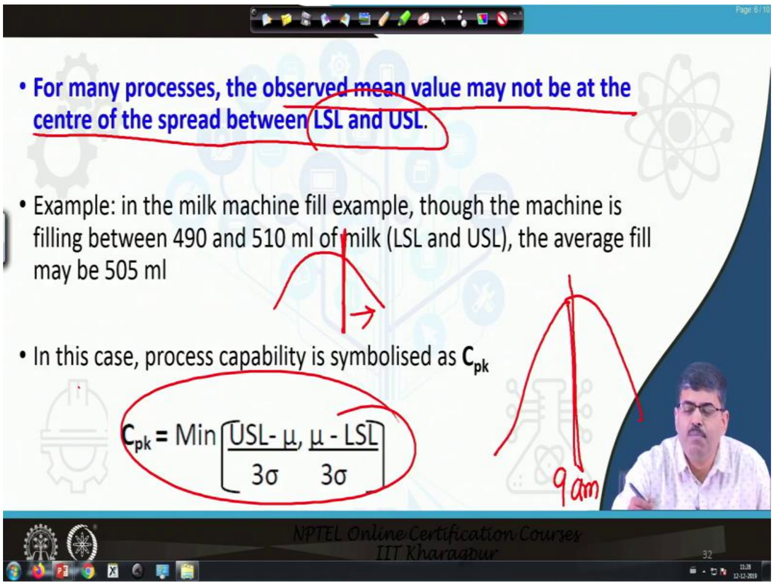

So, if you see, this is where, like there is something called, now all along we have drawn, all along we have, all along we have said that this was my diagram. So, my mean was exactly at the center of the spread. Now, when the mean is not at the center of the spread, then we have to use this formula for six sigma.

When is the mean not at the center of the spread. For example, let us take a situation of your railway train arrival. Now this is the time for the train to arrive, at 9 am. Can the train arrive early? Yes, 1 minute. But will you allow the train to move before 9 am? No, many passengers are waiting to come at 9. Can the train be late? Yes. So, arrival; very rarely is early. Arrival will always be late. So, your curve will not be at the center. The average 9 am will not be at the center. If this is the arrival pattern of the train, your average; it will always be towards on the late side.

So, this is, that is what we want to say; the observed mean may not be at the center of the spread between the lower specification limit and upper specification limit. Then we use this formula. Again, your as like Cp value, as we discussed in the previous class, the Cpk value should also be somewhere near 2. But Cpk will be a bit less. Anyway, so this is this.

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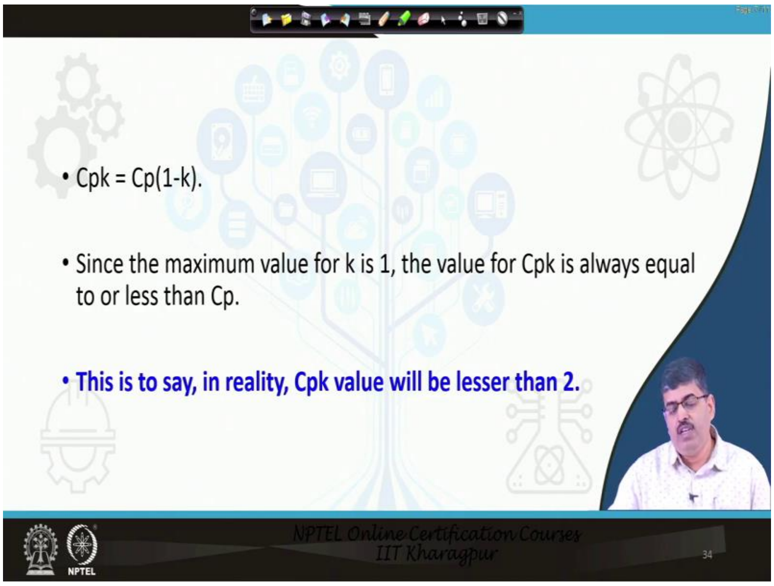

Now, as we said Cpk is equal to Cp into 1 minus k. This is the maximum value for k is 1. The value of Cpk always equal to or less than Cp. This is to say in reality, Cpk value will be less than 2.

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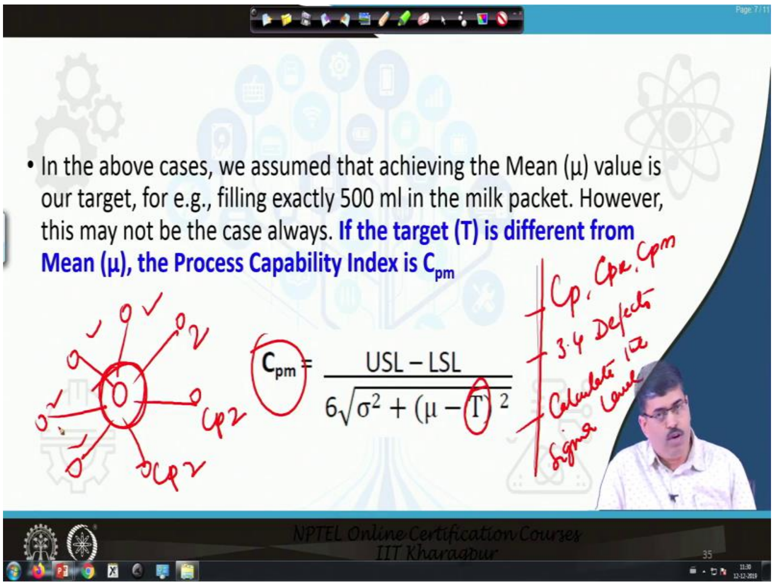

Now, now sometimes target values are given for six sigma. For example; your warehouse order picking. Order picking, your target value for a Cp or a Cpk, whatever you want to say, your order picking sometimes, the target is given. That you have to achieve, if not 2, but at least 1.5. Sometimes this target value is given to you. Now, when you are given a target value, then this is; what is that. This is what is called as the T. When you are given a target value, this is what is called as T.

Then we use a Cp m formula and a T or a target value is brought in the picture. So, six sigma is not a rocket science. What I want to say is, six sigma is basically calculating, finding out, is not at all a rocket science and you must have learned six sigma in different other courses, etc. What you need to understand in six sigma is just 2 or 3 things. One is your Cp, Cpk, Cpm. The second thing that you need to know is 3.4 defects and the third is, to calculate the sigma level. These are the three things that if you know, you can do things properly.

So, imagine a process. This is, these are the activities that have to be coordinated. These are the activities, that have to be coordinated. These are the activities that are to be coordinated in the warehouse. If in each case, we are trying to achieve a Cp value of 2, 2, 2, 2, 2, 2, then my coordination becomes very very easy. That is the entire functioning or objective of six sigma. So, as an exercise, you can easily, I mean try to look at implementing or at least measuring the process capability for your organization or for your department. Now, the other aspect of the six sigma or rather, other aspect of coordination is Queuing. What is happening?

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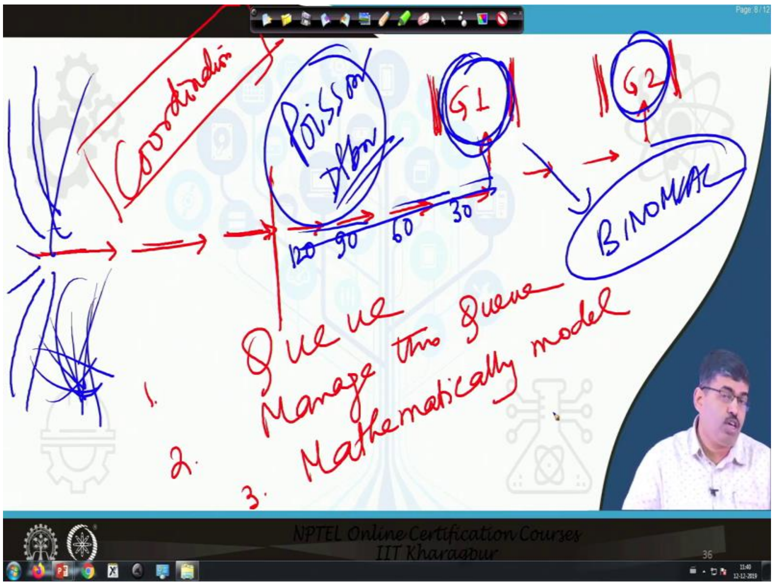

What is happening is, your vehicles are coming in a warehouse, One vehicle after the other, One vehicle after the other and they are waiting at the gate for security check. So, vehicles are in queue. They are waiting at the gate for security check. Once after the papers and all are checked, they are allowed the entry into the warehouse and then, there are only two gates. What are these gates? Gates for loading-unloading. There are only two gates, gates for loading-unloading, two gates for loading-unloading.

But how many vehicles are in queue? Many, Morning time and late night, when the traveling restrictions are removed on the roads, then there will be too many vehicles, who will stand in queue, waiting for their products to get loaded and unloaded. Waiting for their products to get loaded and unloaded. So, if you can; so the first thing is this is a queue and the second thing is, I need to manage this queue. So, if I can math, the third thing is, if I can model this mathematically, when the trucks should arrive, how much time it would take for loading-unloading, etc?

If I can model this mathematically, then my coordination will become very, very easy. Then my coordination will become very, very easy, if I can model this mathematically. So, this is what is called as Queuing Theory Approach to Coordination. Now, this queuing theory, you must have learnt in operations research. Now, here we can apply queuing theory in supply chain modelling for coordination. See, in a warehouse there are so many issues.

Issue number One, morning what will happen. Just appreciate the situation. Morning what will happen In morning, all the, now what is your warehouse dealing with? Your warehouse is dealing with finished products. That means your warehouse stores the finished products. So, who are your customers? Your customers are people, who are the wholesalers and the distributors, of the finished product. Assume you are, you are Hindustan Unilever. So, who are your customers? All the dealers of soaps, shampoos, etc.

So, what will happen in the morning? Right from the morning, the dealers will start calling and through indent, ERP systems and emails, they will start giving orders, that I need these many number of cartons of shampoo bottles, I need these many number of soap bottles, etc, etc. So, every morning the dealers will start ordering.

Now, have you understood up to this? Every morning, dealers will start ordering. Now, this ordering, try to understand, this ordering. Will they come in gaps, will they come in gaps, in stages that means, what I want to say is, one order is coming over phone; at 8 am. The next order is coming over phone at 8:05, third order, 8:15, fourth order; 8:15, fifth order; 8:20.

Will the orders come in like that? No, your phones will keep on ringing parallelly, one phone after the other, one phone after the other and as you see in comedy scenes in the movie, you will pick up 1, you will pick up the next. So, this way. So, your orders will come. So, orders are not queued, your orders are, like here if you see, in this diagram in front of you, the trucks are standing in a queue and each truck will take almost similar time here, each truck will almost, will take almost similar time at this gate, for loading or unloading.

So, each, if the truck takes 30 minutes to load and unload, either load slash unload or both, whatever. If the trucks take 30 minutes for this activity here, definitely the waiting time for this truck is 30 minutes. The waiting time for this truck is 60 minutes, waiting time for this truck is 90 minutes. Because one will have to, it will have to go.

Waiting time for this truck is 120 minutes. So, in this way. So, there is a finite time gap between two processes or two activities. But what is happening in the morning? Your orders are not coming in this manner, your orders are not coming in this manner. Your orders are coming like, dhag, dhag, dhig, dhag, this, this way. Your orders are coming like this. So, if you can solve this using a queuing methodology, then your coordination becomes very very fruitful and helpful. Then your coordination methodology becomes very very fruitful and helpful.

Here, so this is this is actually the next approach to coordination. This is actually the next approach to coordination. That is queueing theory approach to coordination. Now, as just this thing; just continuing with the same diagram. So, what is the arrival pattern? What is the arrival pattern of this or rather arrival pattern of these vehicles the vehicles also, can come in any time. The vehicles also, can come in any time. So, arrival pattern of these, the standing pattern is one behind the other. The standing pattern is one behind the other.

They are in a queue. But their arrival, they can come in from road number 1, they can come in from road number 2, road number 3, road number 4, road number 5, road number 6. So, their arrival pattern is random. They can happen anytime. Arrival pattern is random, it can happen anytime.

So, your arrival follows a Poisson Distribution. So, arrival follows a Poisson distribution and your arrival follows a Poisson distribution and this processing time is 30 minutes. That will not change; it will not be one truck finishes in 5 minutes, another truck will take 1 hour, no. Truck size is same, material inside the truck is also equal weight.

So, roughly, same time will be required for loading-unloading, for every week. So, this processing time for at this gate follows a, what distribution? Follows a Binomial Distribution. So, the arrival is at the Poisson; it can come in any time. But the processing time here is a Binomial distribution. So, this is another aspect; this is a very important aspect in queueing theory. Now I am going to the third question. So, first point is it is a queueing. So, if I can solve this problem, if I can solve this this entire thing, then my coordination becomes very, very easy.

If I can solve the queueing problem, if I can understand how to solve the queueing problem, then my coordination becomes very, very easy. So, you see; what have we learnt is coordination. The first aspect of coordination is managing information distortions. That we did by measuring the bullwhip effect.

The second aspect to coordination is having a very, very, very, very narrow variation. That we learned using six sigma or capability of the process, Cp. The third aspect to coordination, another way to coordinate is by managing the queue. So, queueing theory. So, this and then we will learn about how to measure the overall effectiveness of coordination. So, in our next module, we will pick up queuing theory, thank you.