Modelling and Analytics for Supply Chain Management
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Lecture 03
Decisions and Performance Measures in Supply Chain

Good afternoon. Welcome to module 3 - Decisions and Performance Measures in Supply Network - of our course Modelling and Analytics for Supply Chain Management.

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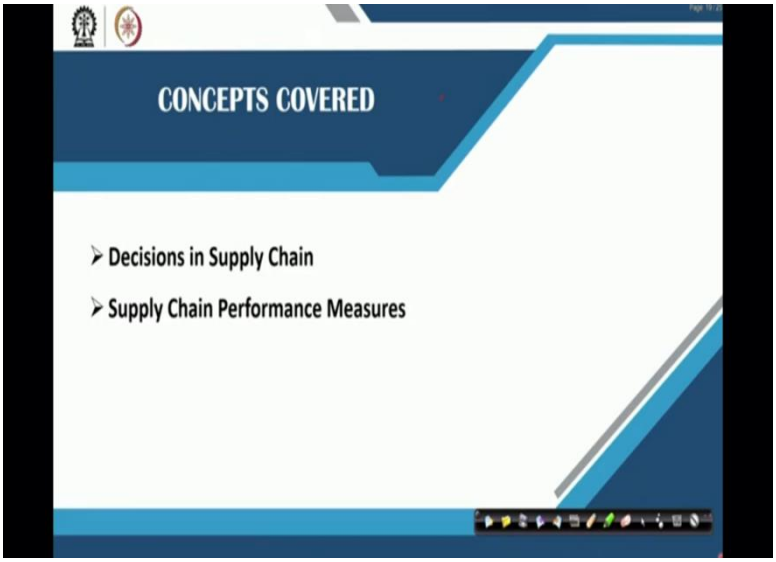

Today we are going to cover mainly 2 concepts. One is on decisions in supply chain. The types of decisions that are taken by different managers in context of supply chain management and the second topic that we would be dealing with is supply chain performance measures. Since, this title of the course is Modelling and Analytics in Supply Chain Management. Basically we will be applying analytical techniques and models for enabling the managers to take decisions related to various problems that they encounter in a supply chain environment.

Now, those basically decisions are data driven decisions and before we apply the models or the analytic techniques, we need to know little bit about the type of decisions that are being taken by the managers in solving problems related to supply chain. So, we start with decisions, the types of decisions particularly, in supply chain.

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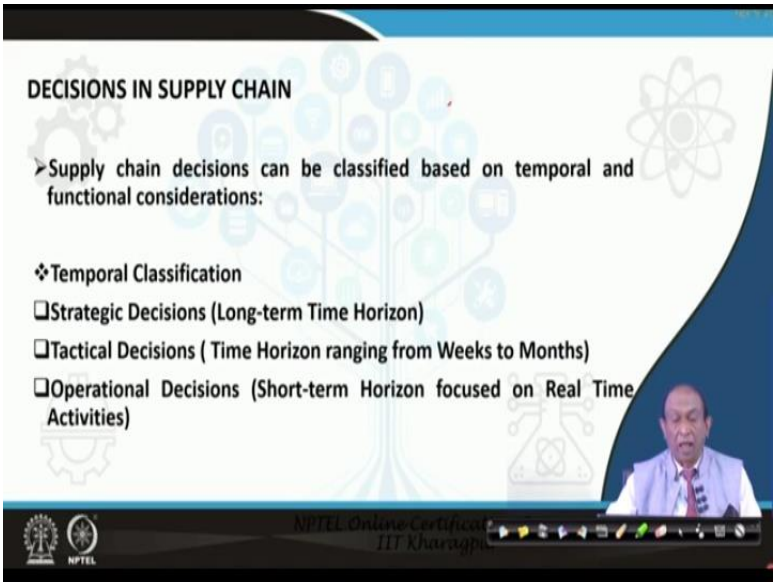

So, supply chains decisions can be classified based on temporal that is dependent on time and functional considerations. Now, if we look at temporal (consi) classification, the three types of decisions that are being taken by managers are strategic decisions. That means these decisions have an impact over a longer time period. So, the time horizon here is a of a long term. Three to five years basis minimum.

Tactical decisions. Here the time horizon ranges from weeks to months and operational decisions, where the time horizon basically is very short. The short time horizon focused on real time activity. That means the types of decisions that they take on a daily basis or maybe, over a period of say, three four days.

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Now, if we look at the functional classifications. Then the types of decisions can be categorized into say, procurement type of decisions, procurement decisions, manufacturing decisions. Then decisions pertaining to distribution of products and services. Then decisions pertaining to logistics and finally we will deliberate on the global decisions extending over multiple functions.

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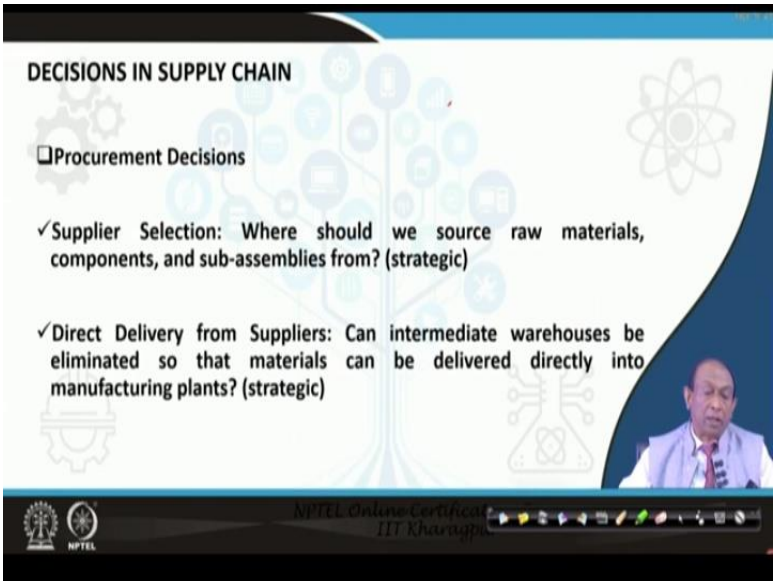

Now, let us look into the types of decisions that the supply chain managers encounter in a procurement type of situation. And we will be only discussing some of those decision types where analytics can play a significant role. So, the first type of

decisions that managers take is related to selection of suppliers. It is not only selections, performance rating which we also known as vendor rating, vendor evaluation and rating, is also enabled through mathematical models or analytics. Particularly in here, multi-criteria decision making types of problems play a greater role.

And now when we see that supplier selection, what are the types of, you know, questions that are solved by managers. The first one is - Where should we source raw materials from? Not only raw materials, raw materials, component and sub-assemblies. Now, these types of decisions is basically a strategic type of decisions because they have an impact over a long period of time, once you select a supplier, you cannot just simply write him off, you know, based on one or two deliveries.

And also it depends upon the type of products, the environment in which you are selecting the suppliers. Then, the next, another type of decisions where mathematical models can play a great role is that whether we will encourage direct delivery from suppliers. Means can intermediate warehouses be eliminated so that materials can be delivered directly from the supplier's source directly to the manufacturing plants. This is also a very, kind of, long term, this has got a long term impact so it is a strategic decision.

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Then, second one is another, like say Vendor Managed Inventories. Should the inventories at the manufacturing plants of a focal company be managed by vendors? It

is a strategic decision. It is also known as VMI. In a Vendor Managed Inventory situation, actually the vendors, they are in charge of controlling the inventory at the manufacturing plant. The vendors, they basically have control over the stocks that are being maintained in the manufacturing premises.

See, they can see and monitor the level of stock that is being there and whenever the stock level falls below a predetermined level, the vendor can decide how much he will order or how much he will send directly to the manufacturing plant. Is more about Vendor Managed Inventories we will see when we talk about inventory analytics slightly later in some other module.

Then, you know, we talk about optimal procurement policy. In here the types of decisions they encounter is that what are the costs and service trade-offs in alternate procurement strategies. Now, these decisions can be either strategic or can be (techni) tactical.

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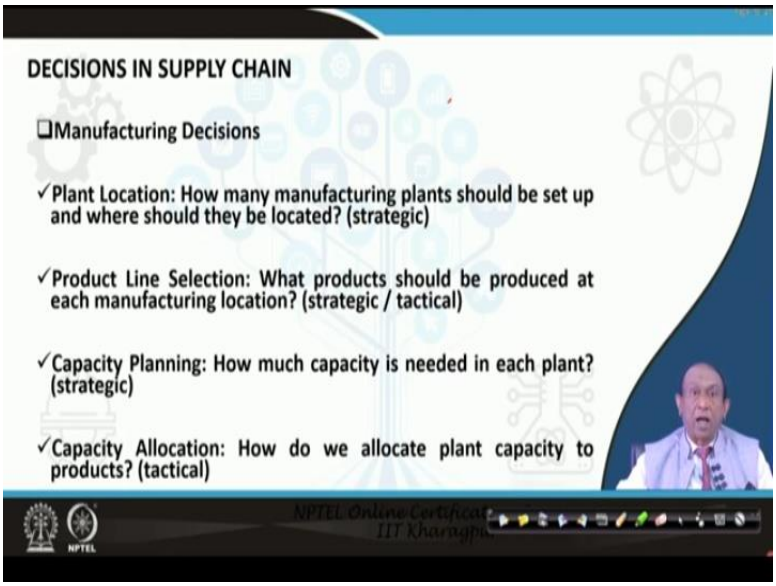

Then we come to decision types related to manufacturing situation. First is, say let us talk about plant location. How many manufacturing plants should be set up and where should they be located? This is a very important facility location type of problems. And the, in subsequent weeks, we will talk about different kinds of model where we will find out how to locate a particular manufacturing plant. In which location should they be situated? And what should be the capacity of each plant or each location, each facility.

So, depending upon the situation we decide the location of facility and capacity of each facility and these are all strategic decisions, because once you take those decisions, you cannot easily reverse it. Then product line selection. What products should be produced at each manufacturing location? This is also either a strategic decision or a tactical decisions. Now the, in a, let us talk about simple product mix type of problem. Here we have applications of linear programming kind of techniques.

All of you have already noted that while solving linear programming problems, the first type of problem that you encounter is the product mix problem. Now, what are the different types of products to be manufactured in what quantity? So, subject to certain constraints like capacity of the plant, availability of raw materials, availability of raw material, the labour, availability of labour and the overall objective is either to minimize the total cost or maybe, you know, to maximize the contribution. But in a real life situation these kind of problems can be extended to production distribution type of problems.

In a (prod), suppose a plant or a company and an organization has got multiple plants. So, in a multi-plant multi-product situations, you know how much should be produced in each of the manufacturing plants, in each of the different types of shifts that they operate and besides the production decision, how much quantity of each of the product types should be shifted from or transferred from each of the manufacturing plants or each of the different warehouses, if there are multiple warehouses.

So this basically a combined production distribution problem such that total cost of production as well as transportation or distribution in minimized, subject to constraints like the overall plant capacity cannot be, you know, exceeded. There may be constraints related to the availability of labour, there can be constraints in the sense of availability of material and there can be also other constraints like, you know, this much amount of finished goods inventory must be available at each of the warehouses and also at the plant level.

Now, this kind of problems can be, you know, formulated as a production distribution problem. Then let us talk about capacity planning decisions or capacity planning problems. Here, the question is how much capacity is needed in each of these plants is

a strategic decisions. Then capacity allocation - How do we allocate plant capacity to products? Then it becomes a tactical problems.

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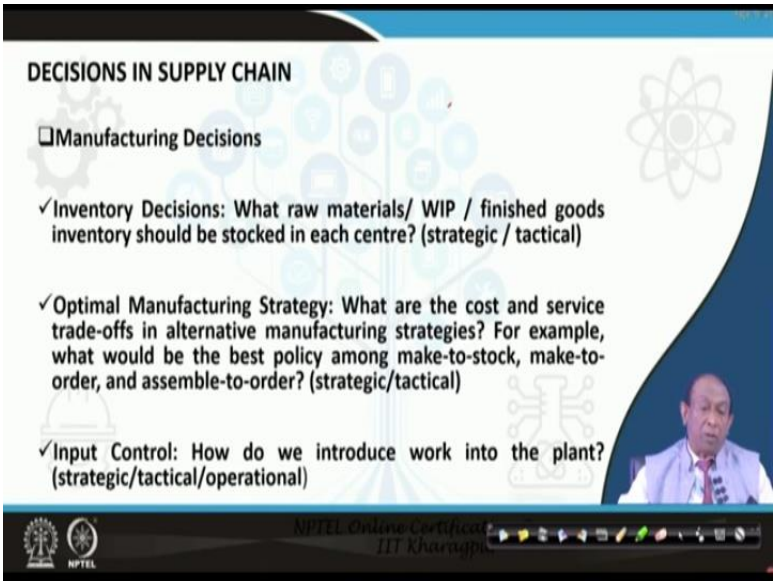

Then, in the manufacturing environment one of the most important area is to take decisions related to how much stock should be maintained at each of these manufacturing plants, what raw materials or work-in progress inventory or finished goods inventory should be stocked in each of these centres. See, this also a strategic or a tactical problem.

Then let us talk about optimal manufacturing strategy. What are the cost and service trade-offs in alternative manufacturing strategies? For example, what would be the best policy among say, make-to-stock, make-to-order and assemble-to-order? So, this is also a strategic or tactical decisions. Then another typical problem that managers encounter is that - How do we introduce work into the plant? This can be either a strategic or a tactical or an operational decision.

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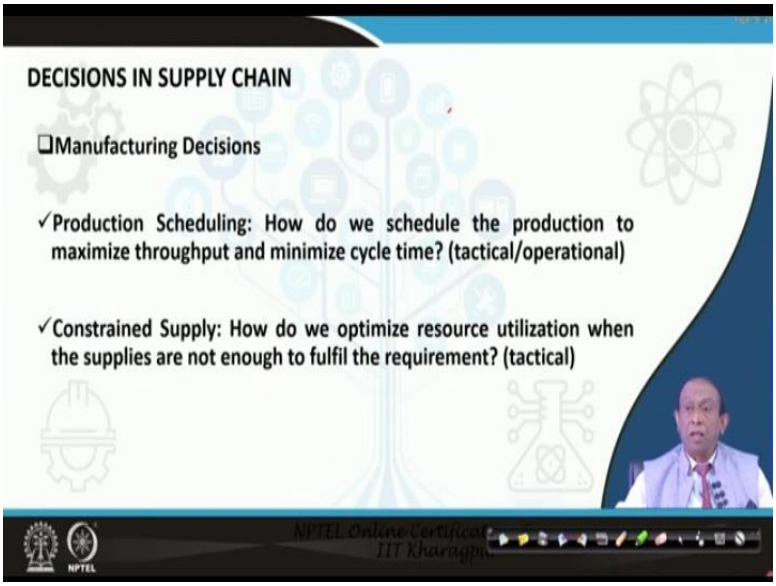

Then another important area which is of interest not only for the production people but to academicians also, is the area of production scheduling. How do we schedule the production to maximize the throughput and minimize the cycle time. These are tactical or operational type of problems. Here, we find that in the current day context lots of algorithm have been developed.

Lots of, you know, heuristics have been developed so that, you know, a particular objective is satisfied. Like say, I would like to reduce the total elapsed time or say in terms of production decision we want to maximize the throughput or minimize the total elapsed time and under constrained supply condition, how do we optimize resource utilization when supplies are not enough to fulfil the requirement? This is basically a tactical problem.

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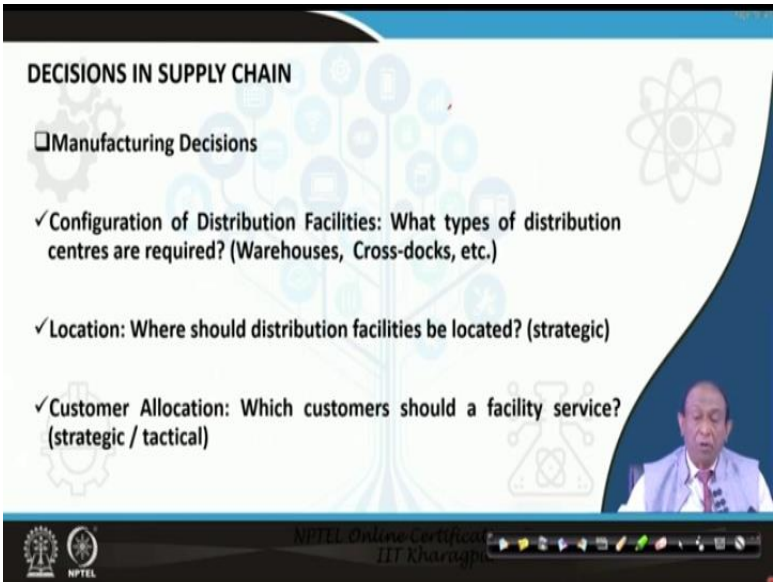

Configuration of distribution facilities. What types of distribution centres are required? Warehouses or cross-docking, et cetera, this also forms a part of a manufacturing decisions that mangers encounter with. Where should this distribution facilities be located?

Now, we will talk about all these types of problems, somewhere when we discuss about design of distribution networks. We will talk about the different types of network design and how analytics can play a role in deciding the optimal configuration of this distribution structure. Then customer allocation, which customers should a facility service? This is also either a strategic or a tactical decision.

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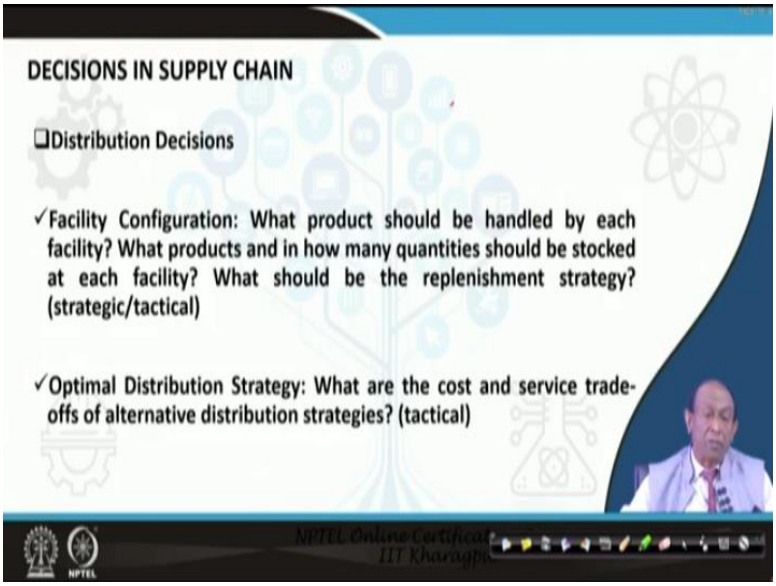

Now, when we look at distribution decisions, the first thing that we had already mentioned about is a facility configuration. What product should be handled by each facility? What products, I mean, how many quantities should be stocked at each of these facilities? What should be the replenishment strategy of these kind of products in each of these facilities? This is also a strategic or a tactical decisions.

Now, let us talk about optimal distribution strategy. What are the cost and service trade-offs of alternative distribution strategies tactical? Here lots of operations research models can play a very important role in deciding optimal distribution strategy.

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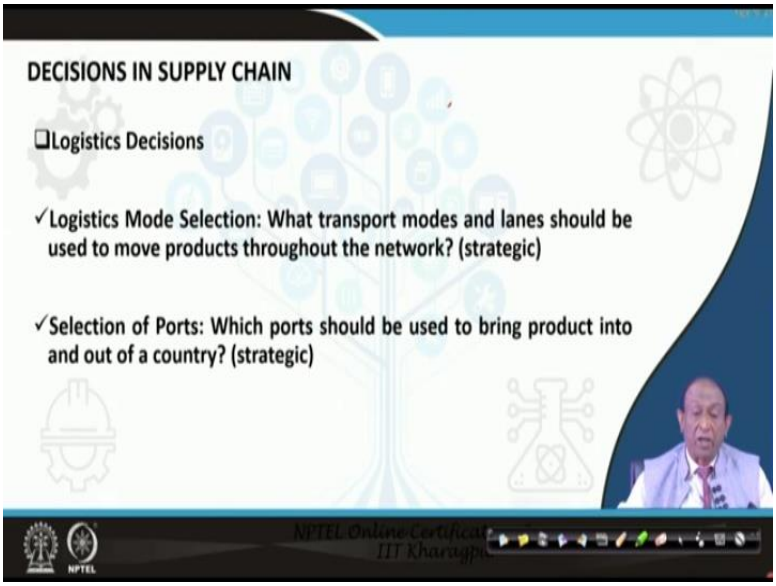

Let us talk about logistical decisions, logistic decisions. Logistics mode selection - What transport modes, whether the materials should be sent by sea, air, road, rail and which lanes should be used to move products through the network? In here, lots of decision support systems based on mathematical models are applied by the managers.

Vehicle routing problem is a very important problem and lots of heuristics, for example, Clarke and Wright's algorithm or if an optimization problems like travelling salesman's problem can be adapted but, analytics play a very significant role here in minimizing that total computation time to find out a realistic and a schedule or a vehicle track or vehicle route scheduling.

Then selection of ports. Which ports should be used to bring products into and out of a country? So, these kind of problems the managers encounter when they basically, you know, take certain decisions related to global sourcing.

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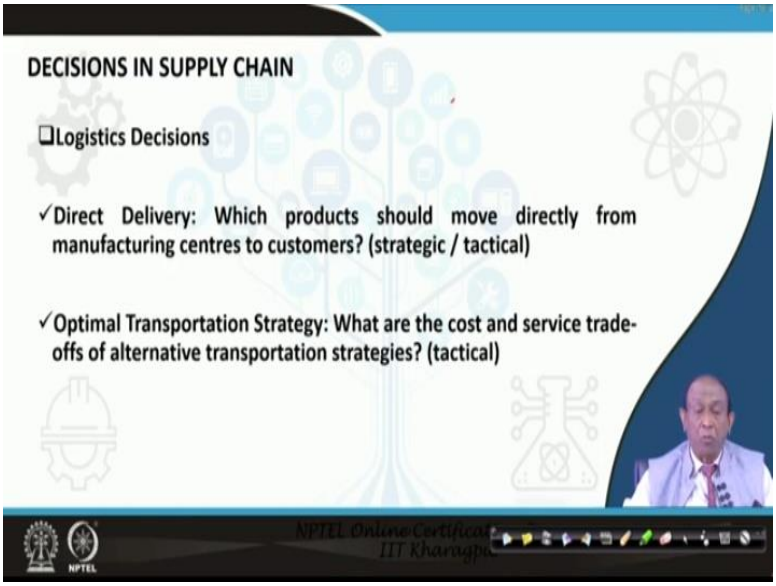

Then which products should move directly from manufacturing centres to customers? This is a situation I had already mentioned is called drop shipment. So, drop shipment decisions are taken based on certain mathematical models. Optimal transportation strategy - What are the cost and service trade-offs of alternative transportation strategies? This maybe tactical but has got a vital impact on day-to-day affairs of the organization.

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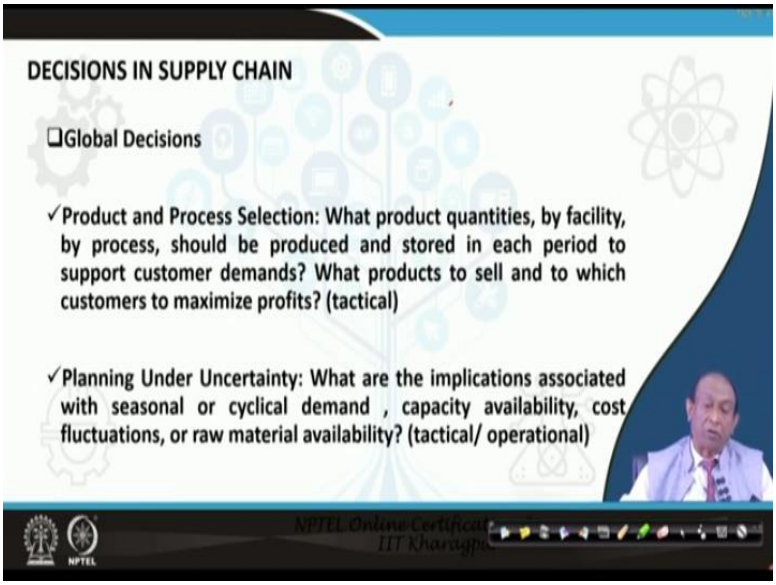

Let us talk about global decisions. Product and process selection - What product quantities by facility, by process, should be produced and stored in each period to

support customer demands. What products to sell and which customers to maximize profits? This becomes also a tactical problem.

Planning under uncertainty also play a significant role in supply management decisions. What are the implications associated with say seasonal or cyclical demand, capacity availability, cost fluctuations or raw materials availability? This may be a tactical as well this can be a operational.

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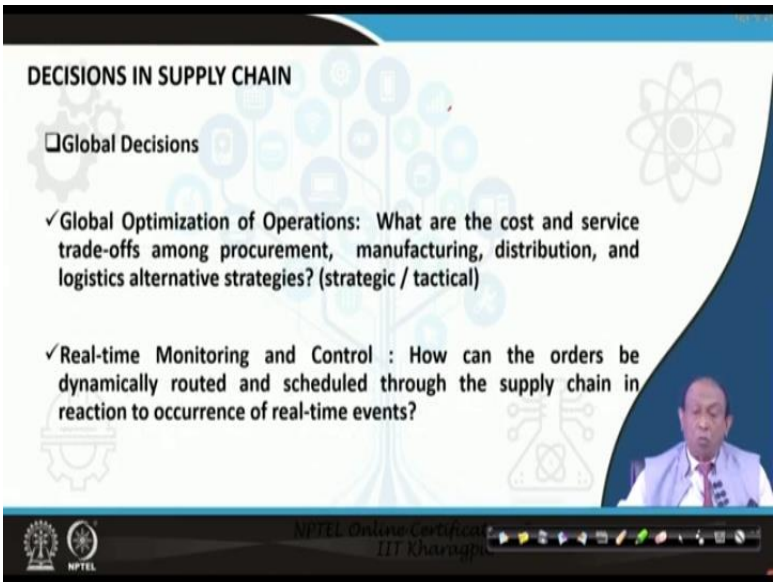

Global optimization of operations - What are the cost and service trade-offs among procurement, manufacturing, distribution, and logistics alternative strategies? It can be a strategic decision. It can always be, it can also be a tactical problem. Real time monitoring and control - How can the orders be dynamically routed and scheduled through the supply chain in reaction to occurrence of real-time events?

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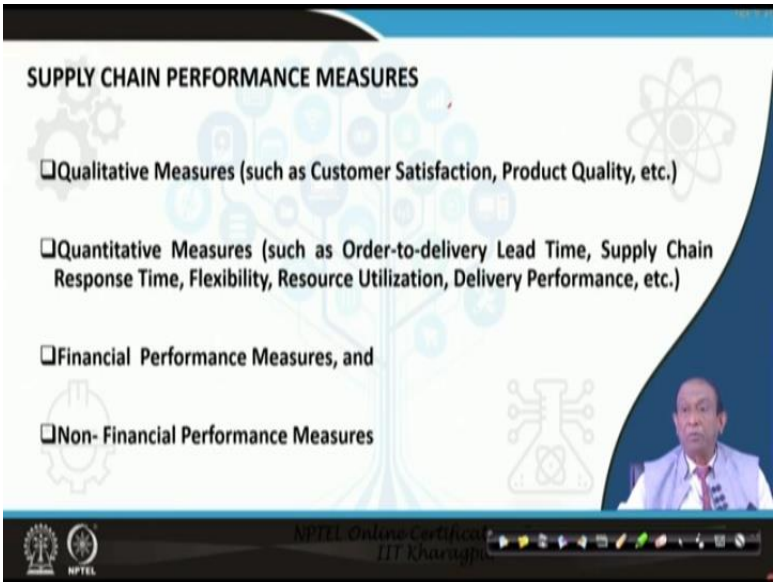

Now, having been familiar with the types of decisions that managers take in a supply network environment, let us talk something about the various supply chain performance measures because until and unless we are familiar with certain key performance indicators or performance measures, we will not be able to formulate mathematical models or will not be able to finalize the objective of a particular problem.

Now, in many situations we might not find any readymade KPIs which is called Key Performance Indicators available in the literature. Sometimes, based on the problem situation or depending upon the research that we are undertaking, we have to design a Key Performance Indicator or we have to formulate a particular performance measure and depending on that sometimes new algorithms need to be developed.

So, when we talk about performance measures, there can be two different types of performance measures. One may be qualitative measures, for example, customer satisfaction, product quality, which is a function of several qualitative attributes. And there can be quantitative measures, for example, order-to-delivery lead time, supply chain response time, flexibility, resource utilization, delivery performance, et cetera.

Now, there can be financial performance measures as well as non-financial performance measures. So, we have to find out that, you know, with respect to each of these, let us get familiar with some of the commonly used performance measures.

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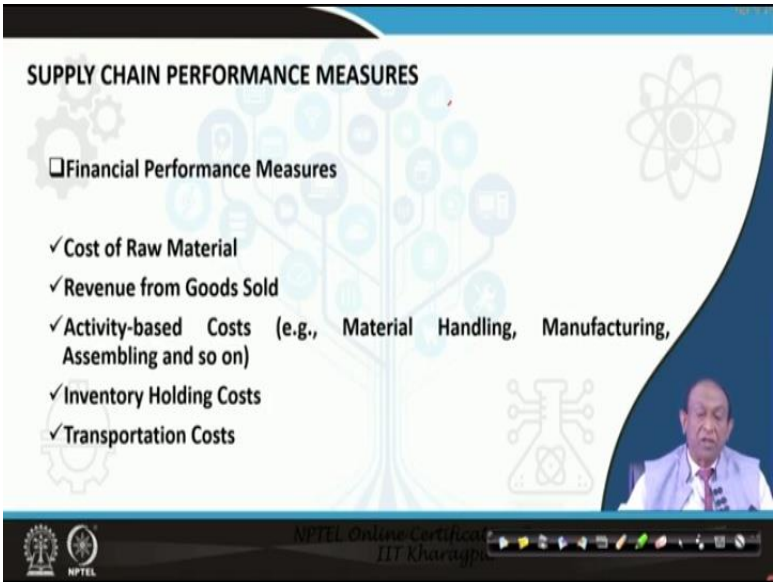

First, let us talk about financial performance. In here, the commonly used measures are the total cost of raw materials, revenue from goods sold, activity based cost. For example, the total cost incurred for material handling, manufacturing, assembling and so on. Then, there can be, you know, situations where you have to determine what is the cost of carrying inventory that means, inventory holding costs, transportation costs. These are all measures related to financial aspects.

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Then, when you talk about financial performance measures, sometimes in many situations where a retailer or a wholesaler is dealing with goods which are basically perishable in nature. What is the total cost of expired perishable goods? What are the penalties for late delivery of orders to customers? What is the total amount of credits from suppliers for their late deliveries? What is the total cost of goods returned by customers? Because if you are supplying defective materials to customers obviously, this will subject to returns and, that is part of the reverse logistics, ok, or reverse flow.

The cost of goods returned by the customers need to be computed for finding out action plans to improve the quality of materials that we are supplying to customers. Each of these KPIs will have certain managerial implications and that must be also understood in the context of the problem that we are going to solve. Then, what is the total amount of credits for goods returned to suppliers and so on. Because the suppliers may be also sending us defective or bad quality materials. So, in that case, you know, what is the total amount of credits for goods that we have returned to suppliers, need to be also computed.

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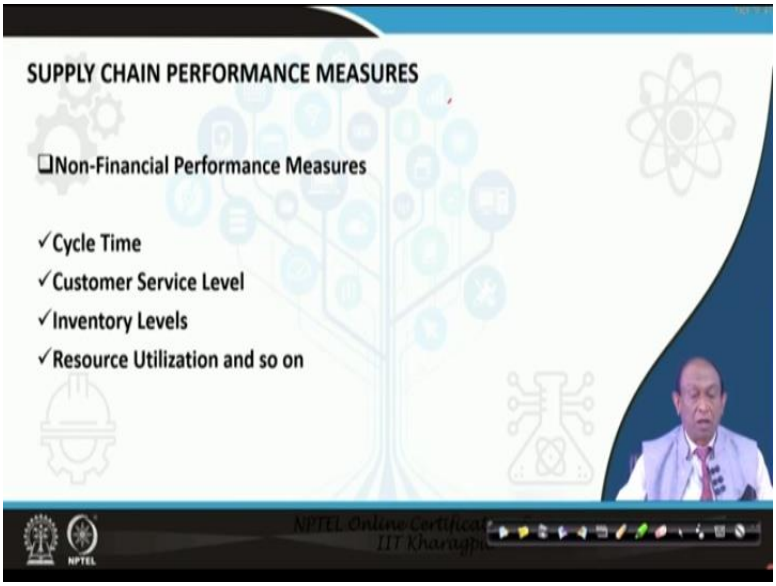

Then let us talk about certain non-financial performance measure. The, one of the most important and commonly used performance measures which is non-financial in nature is cycle time that is also sometimes known as total-elapse time. Then, customer service level and then inventory levels and resource utilization and so on. Now, we will talk about each of these in detail, in subsequent slides.

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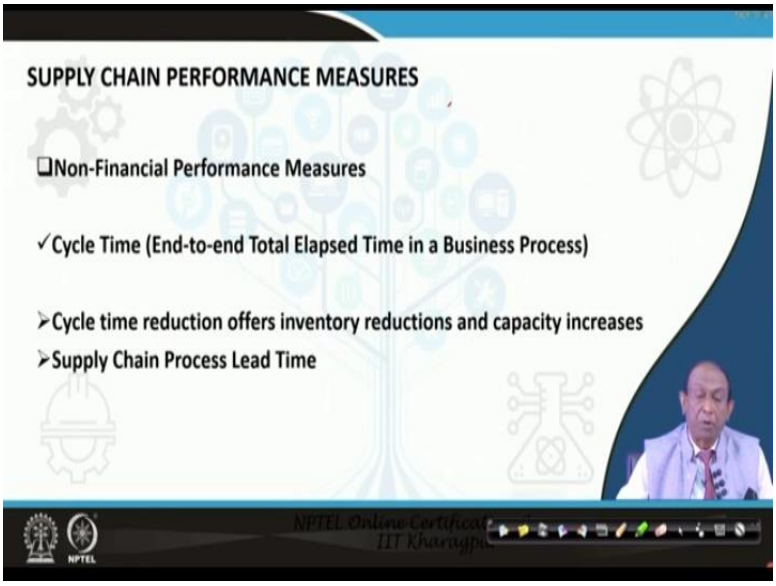

Non-financial performance measures, for example, cycle time. Cycle time is also basically known as end-to-end, total elapse time with respect to a business process.

And this cycle time reduction offers inventory reductions and capacity increases. Supply chain process lead time is also basically equivalent to cycle time.

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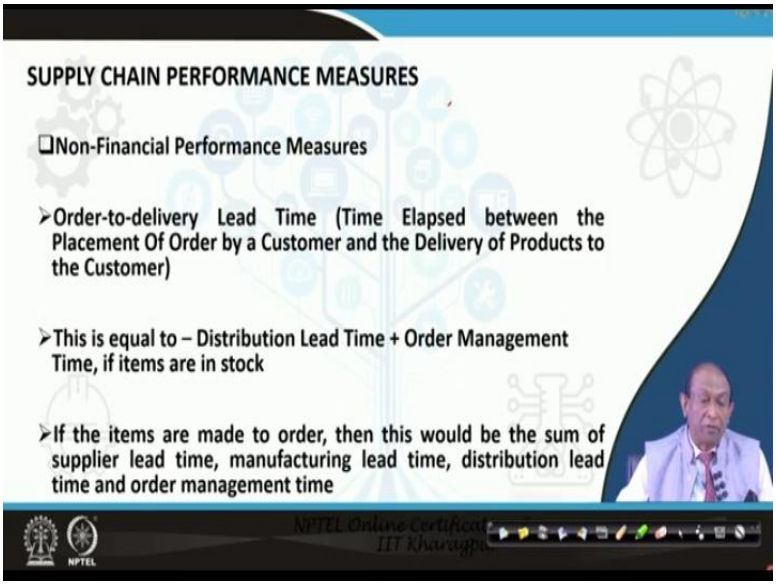

Order-to-delivery lead time is a very popularly used non-financial performance measure. What do we mean by order-to-delivery lead time? It is the total time that is elapsed between the placement of order by a customer and delivery of products to the customer. So total time between placement of order by a customer and the delivery of products to the customer. So this is equal to the distribution lead time plus the order management time if items are in stock.

Distribution lead time is basically the delivery lead time, one aspect of delivery lead time and then you have to it the order management time which will basically consist of, you know, validating the orders. Validating the credit position from the, of the customer and things like that. So, many cheques are encountered that we can talk about it in a different context. Then, because that all those consumes time. If the items are made to order, then this would be the sum of supplier lead time, manufacturing lead time, distribution lead time and order management time.

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Then, we talk about supply chain process lead time which is a very important key performance indicator. So, supply chain process lead time is equal to supplier lead time plus manufacturing lead time plus distribution lead time plus logistics lead time for transport of raw materials from suppliers to plants plus the lead time for transport of semi-finished, finished products in and out of intermediate storage points.

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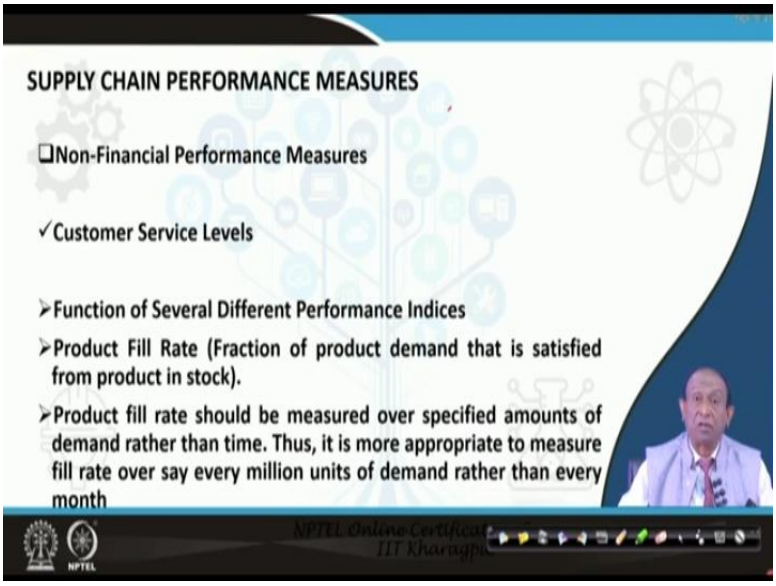

Next, let us talk about customer service levels. This customer service levels is basically a function of several different performance indices and one of the most important is the product field rate. The product field rate is basically the fraction of

product demand that is satisfied from product in stock. Product field rate should be measured over a specified amounts of demand rather than time. Thus, it is more appropriate to measure field rate, say over say every million units of demand rather than every month.

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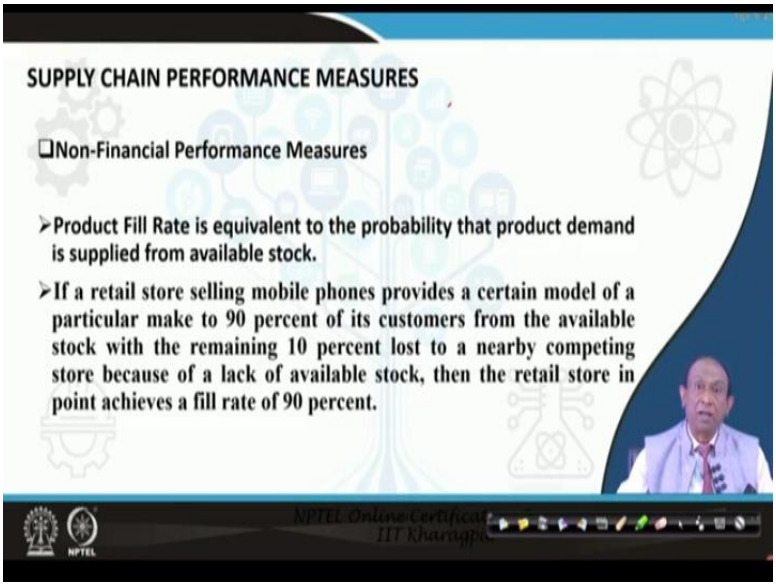

So, product fill rate is equivalent to the product demand is supplied from available stock. For example, if a retail store selling mobile phones provides a certain model of a particular make to 90 percent of its customers from the available stock with the remaining say 10 percent lost to a nearby competing store because of a lack of available stock, then the retail store in point achieves a fill rate of only 90 percent.

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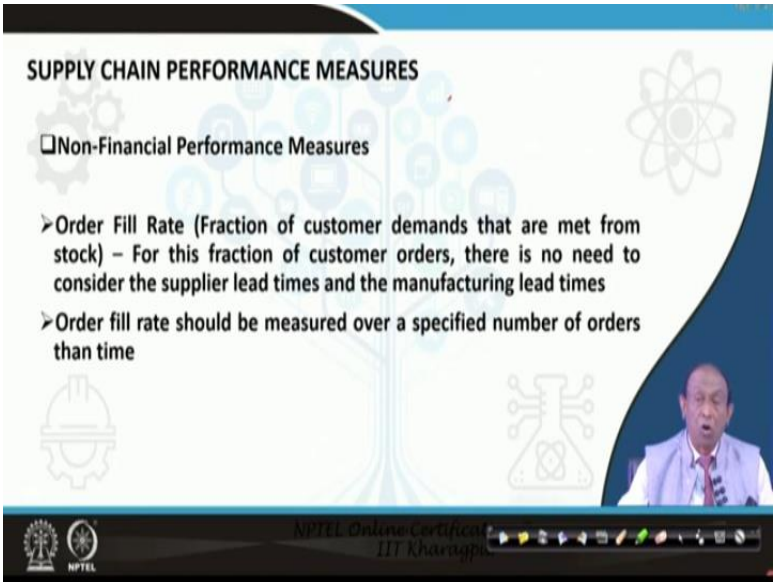

Then, just after product fill rate, we have to discuss about order fill rate. What is order fill rate? Order fill rate basically refers to the fraction of customer demands that are made from stock. For this fraction of customer orders, there is no need to consider the supplier lead time and the manufacturing lead time. Now this order fill rate also should be measured over specified number of orders than time.

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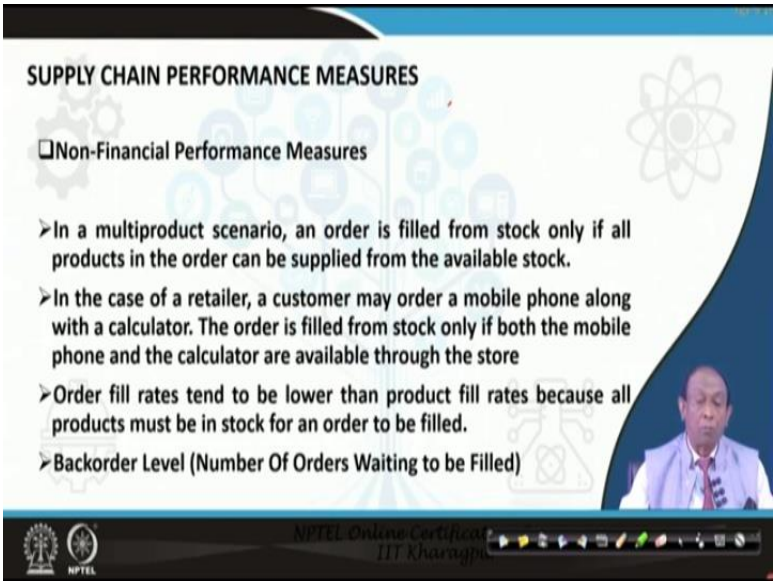

For a for example, in a multiproduct scenario, an order is filled from stock only if all products in the order can be supplied from the available stock. For example, in the case of a retailer a customer may order a mobile phone along with a calculator. The

order is filled from stock only if both the mobile phone and the calculator are available through the store.

Now these order field rates tend to be lower than these product field rates because all products must be in stock for an order to be filled. Then, another important KPI is a Backorder level which is basically the number of orders waiting to be filled.

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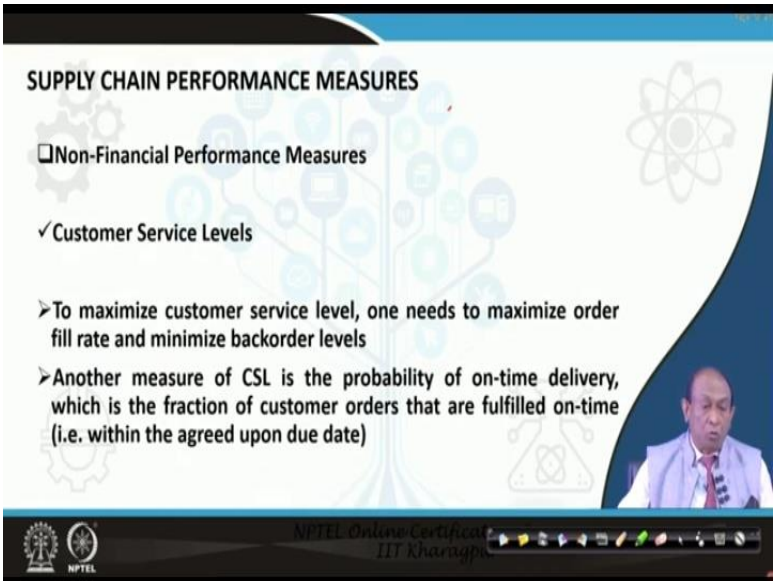

So, maximize customer service level. One basically needs to maximize this order field rate and minimize backorder levels. Another measure of customer service level is the probability of on-time delivery which is the fraction of customer orders that are fulfilled on-time, that is, within the agreed upon due date. In a separate context, we will find another definition of customer service level which is basically the fraction of the replenishment cycles, ok, where the total demand is being made that this particular thing we will discuss when we talk about inventory analytics.

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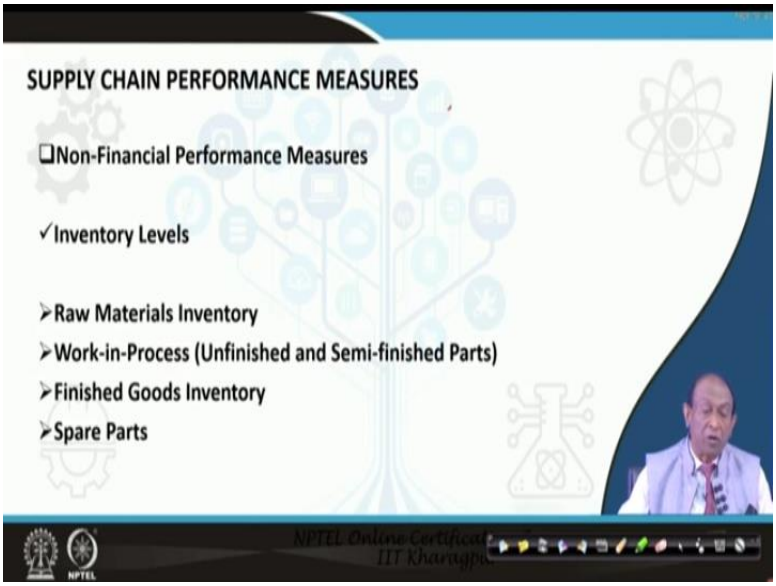

Along with the other non-financial measures when we talk about inventory, we come across lots of KPIs related to what is the total amount of raw materials inventory held. What is the work-in-process inventory, like, including both unfinished and semi-finished parts? What is the total amount of finished goods inventory? What is the total amount of spare parts inventory?

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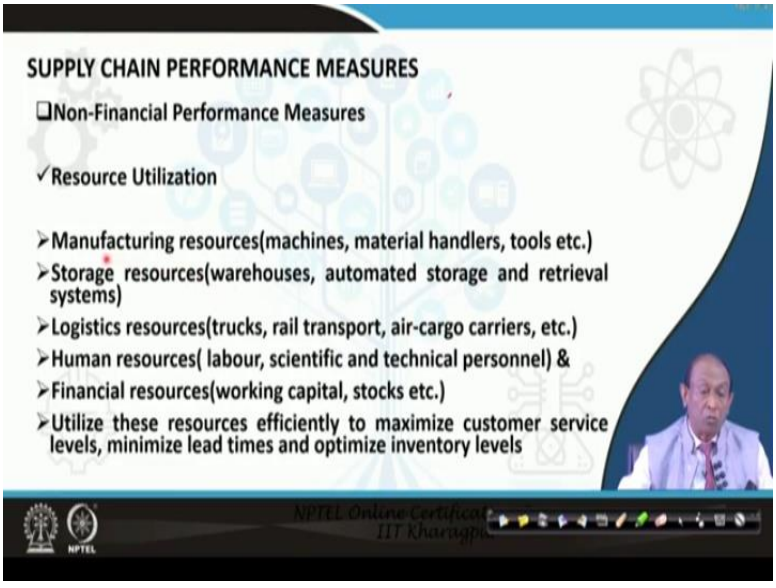

Then when we talk about resource utilization, we need to basically look at manufacturing resources. Do you know to what extent these resources are being utilized? Manufacturing resources, consisting of machines, material handlers, tools, et

cetera, whether there is any ideal time encountered with this? To what extent these assets are utilized? Because asset utilization is also another major of the efficiency of the plant. Storage resources, logistic resources consisting of trucks, rail transport, air-cargo carriers, et cetera.

Then, what is the extent of utilization of human resources? For example, labour, scientific and technical personnel. And then, what is the amount of utilization of the financial resources consisting of working capitals, stocks, et cetera. Basically, all managers utilize this resource or try to basically utilize these resources efficiently to maximize customer service levels, minimize lead time and optimize inventory levels.

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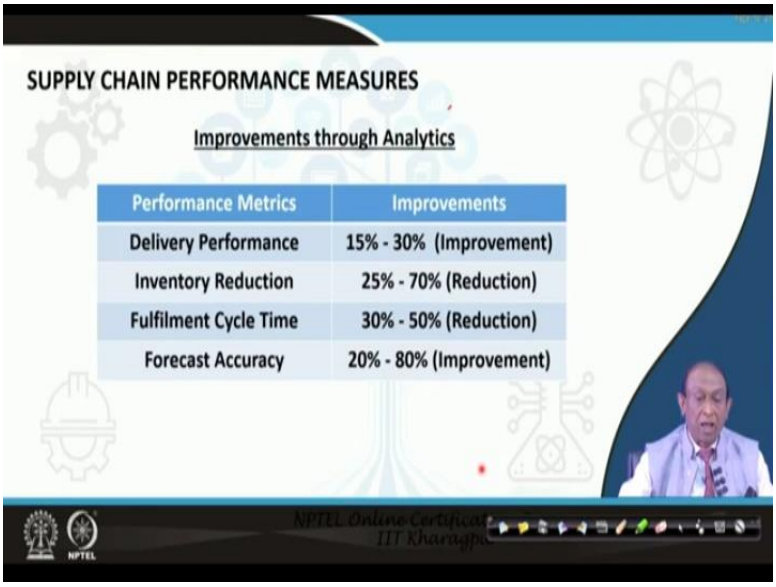

Now, with the help of analytics the kind of improvements that we have seen in the Indian context with respect to different performance matrix, we have a, you know, some statistics related to that. For example, with respect to delivery performance, the improvements achieved is between 15 percent to 30 percent. Inventory reduction, we have achieved 25 percent to 70 percent reduction by the application of mathematical models and analytics techniques. Fulfilment cycle time, we have achieved 30 percent to 50 percent reduction. The Indian managers have achieved a 20 percent to 80 percent accuracy in forecasting the demand for parts by using analytics.

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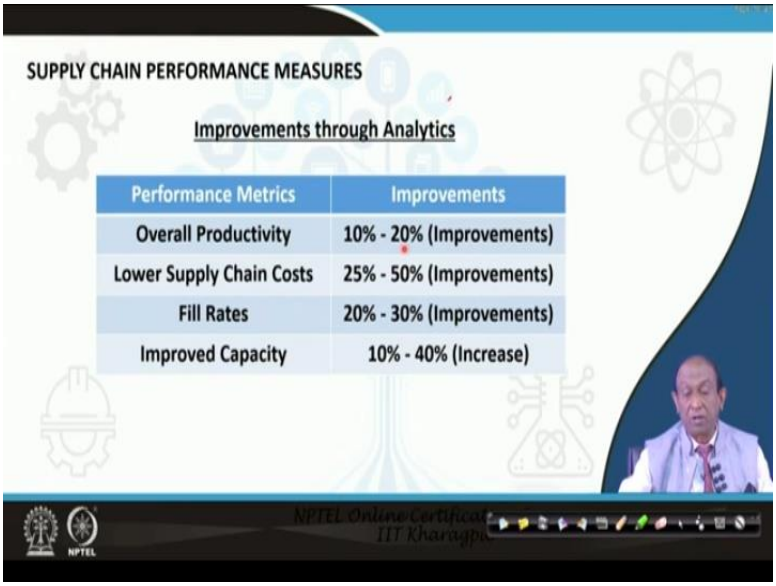

Then overall productivity gain through use of analytics has been 10 percent to 20 percent. Lower supply chain costs - 25 percent to 50 percent. Field rate improvement between 20 percent to 30 percent. And improved capacity between 10 percent to 40 percent.

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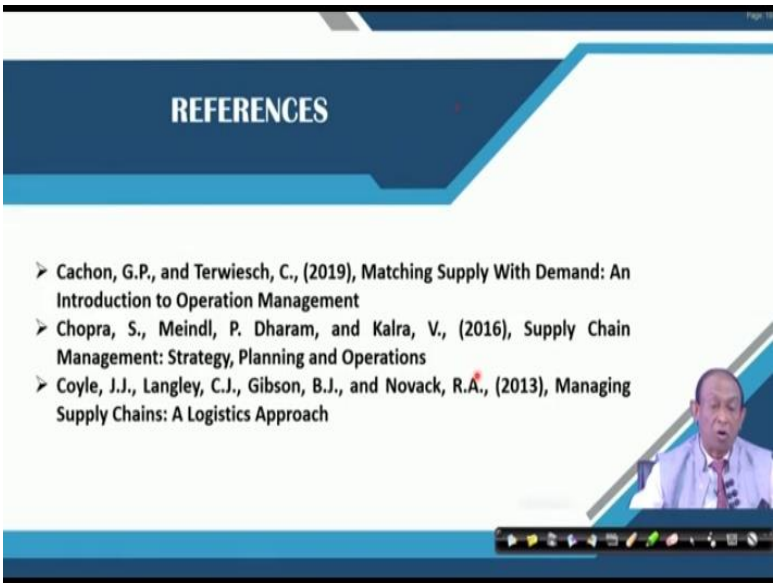

Thank you all. This all what we wanted to discuss on decision, types of decision and performance measures used by mangers in the context of supply environment. Thank you. Goodbye.