Modelling and Analytics for Supply Chain Management
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Lecture 5
Analytics Framework Based on SCOR Model

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To module 5 on analytics framework based on SCOR Model as part of our course on modelling and analytics for supply chain management.

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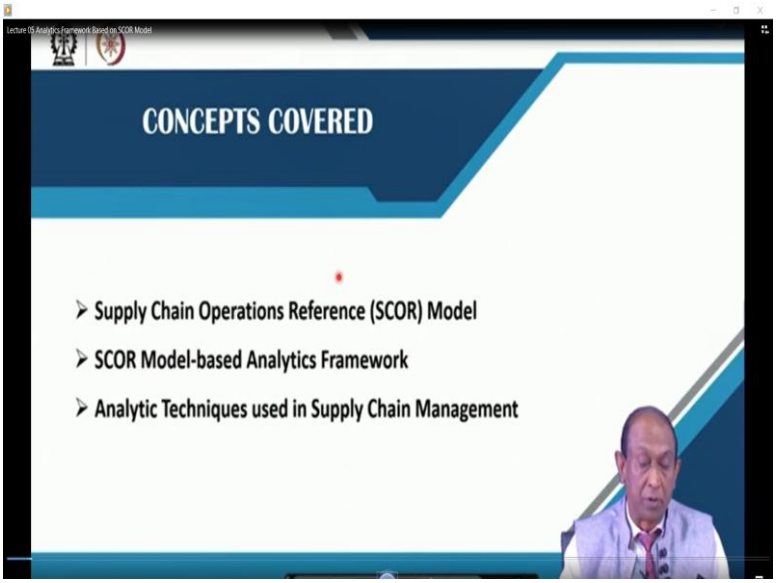

Today we are going to cover the following concepts on, supply chain operations reference model which is also known as the SCOR model, SCOR model based analytics framework and analytic techniques used in supply chain management.

Although, we will be giving you a flavor of the various techniques that are used for decision making in supply network, we will not go into the details of each and every technique in this course. But today I will give you a complete broad spectrum, an idea of what is really meant by supply chain analytics, what are the different areas where this kind of techniques are applicable.

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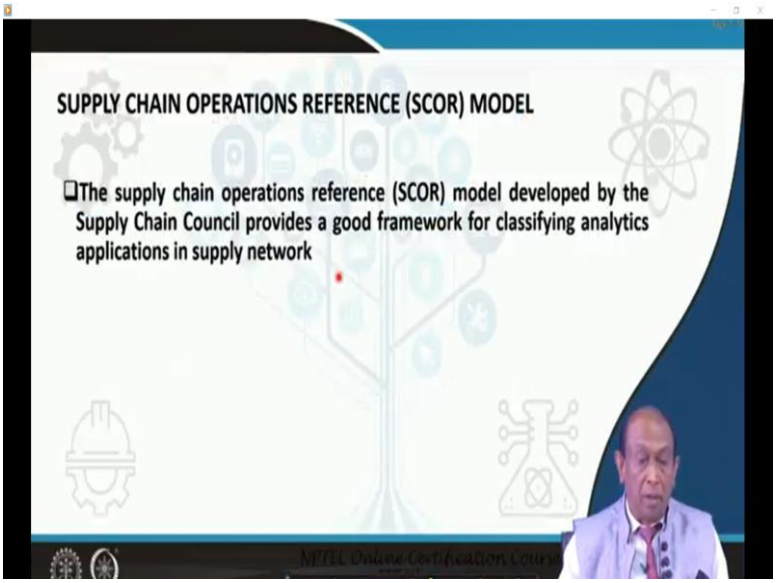

First let us start with this supply chain operations reference model. The supply chain operations reference model which is also known as SCOR model as I have already told you, was developed by the supply chain council. It provides a good framework for classifying analytics applications in supply network.

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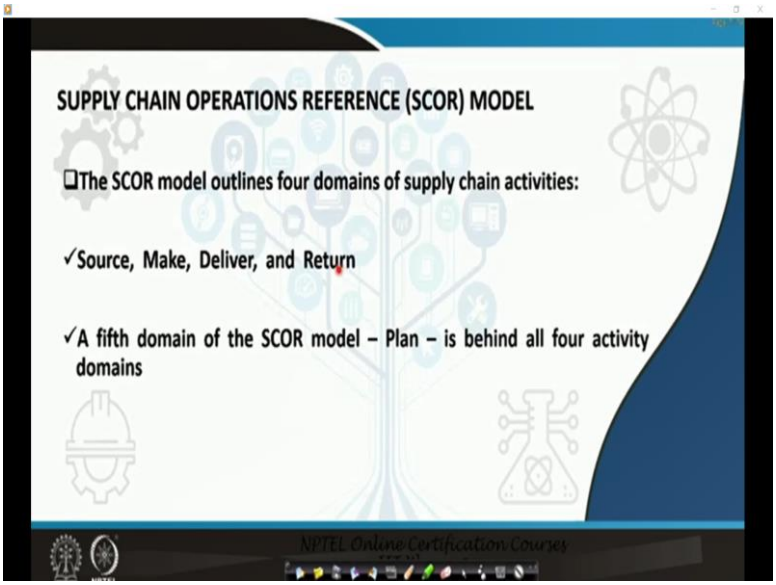

The SCOR model basically outlines four domains of supply chain activities. What are these four domains? Source, make, deliver and return a fifth domain of the SCOR model that is the plan is behind all these four activity domains.

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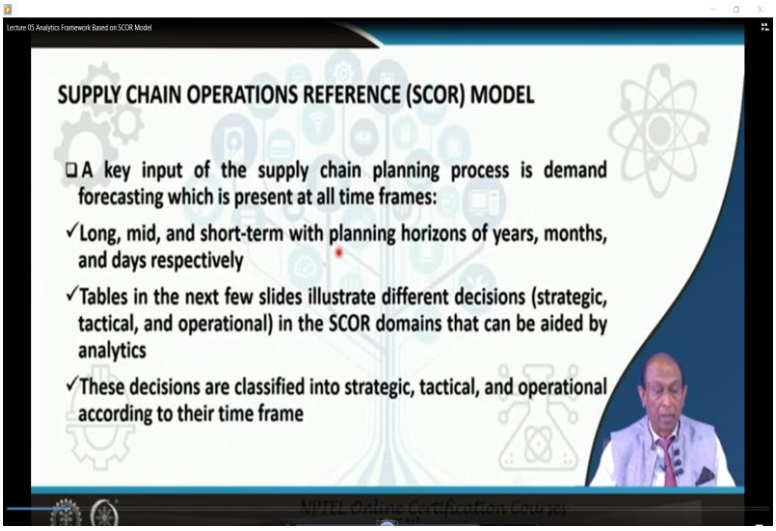

A key input of the supply chain planning process is demand forecasting which is present at all time frames. Long, mid and short term with planning horizons of years, months and days respectively. Will be showing you some tubulars illustration in the next few slides to display the different types of decisions. Strategic, tactical and operational in the SCOR domains that can be aided by analytics. These decisions are classified again into strategic, tactical and operational, according to their time frame.

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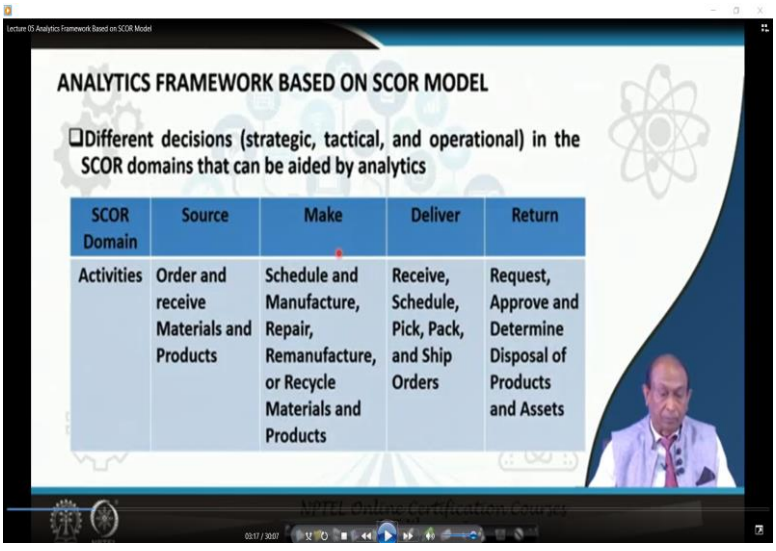

Now, if you look at this particular table, then you see, this particular table basically illustrates what are the different types of activities that are carried out at different phases of the SCOR

model. See, under sourcing what we basically are engaged in, as supply chain specialists, we order and receive materials and products. So sourcing is basically to place order on to their suppliers and receive the consignment of material from and products from the suppliers.

In the make phase the basic concern is scheduling and manufacturing, repairing re-manufacturing or even recycling, in case of reverse logistics, materials and products. So recycling of materials and products as well as repair and remanufacturing normally is concerned with, when there is a customer return through the return cycle.

In the delivery phase or the deliver phase, we are basically concerned with receiving the order or the manufacturer product into our warehouse, and then from there, we basically schedule, pick, pack and ship orders onto the customers. And in the return phase, the activities that are normally under taken are, request, approve and determine disposal of products and assets.

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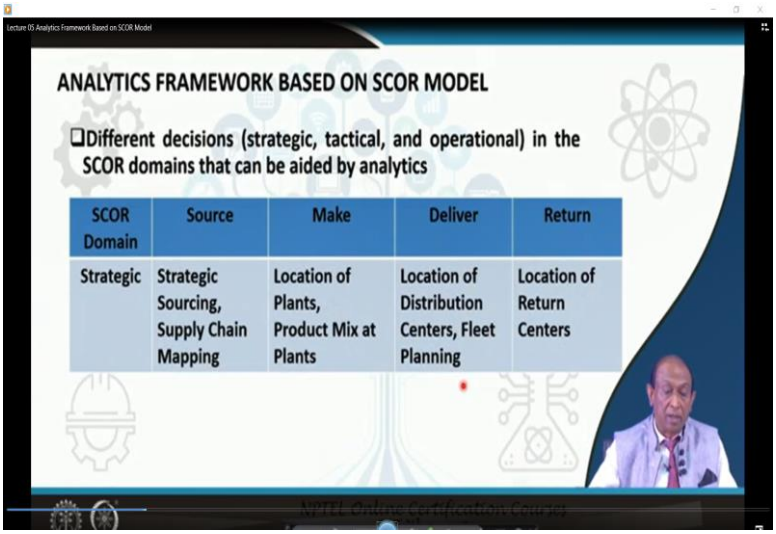

Now, if we again look at the temporal classifications under the strategic domain, under the strategic time frame, sourcing basically includes strategic sourcing, supply chain mapping. Make phase under strategic a consideration, is mainly dealing with location of plants and determination of product mix at plants.

In the deliver phase, what are the different kinds of activities or the decisions that are taken a location of distribution centers, fleet planning these are typical examples carried out in the deliver phase and strategic activities under the return phase, is the location of return centers. This is again pertaining to reverse logistics or reverse supply chain. Also sometimes as part of the closed loop supply chain, this location of return centers, this is also very important. This is a strategic decision because once you take this decision, you cannot easily reverse it.

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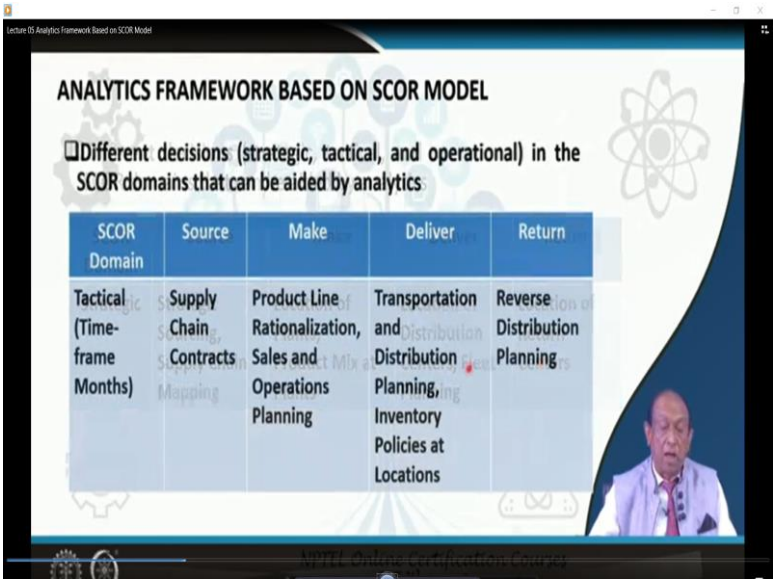

Under the tactical frame, what we find that here the time period is in term of months and under sourcing, what we are basically dealing with is development of supply chain contracts and execution of the same. Make contract administration also plays a very important role. So design of contracts, administration of contracts are very important activities under the sourcing phase.

In the make phase, we are bothered about product line rationalization, sales and operations planning. In the delivery phase, transportation and distribution planning, inventory policies at locations and again reverse distribution planning is the primary activity that is taking place in the return phase under tactical time frame.

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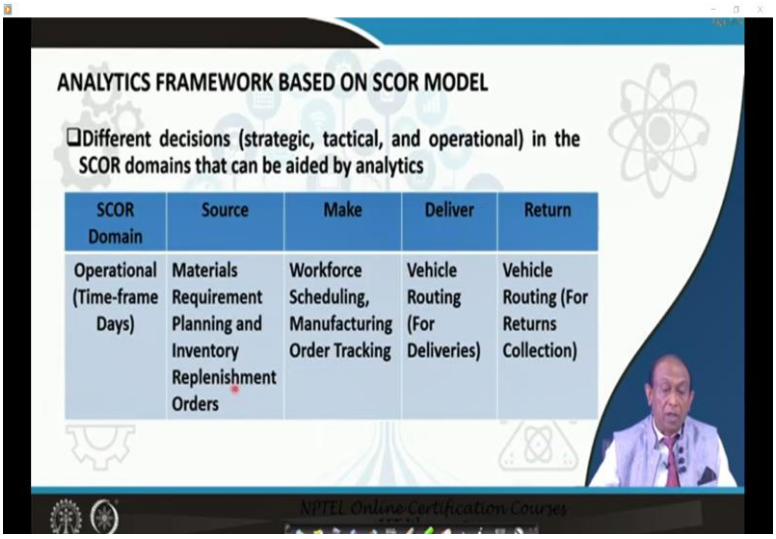

In the operation time frame, which is expressed in terms of days, if we look at the activities that are carried out under sourcing are basically materials requirement planning and

replenishment of orders, inventory replenishment. In the make phase, we are bothered about workforce scheduling, manufacturing order tracking. In the delivery phase, the main problem is vehicle routing, for delivery of orders to customers. And in the return phase is vehicle routing but for returns collections from the customers.

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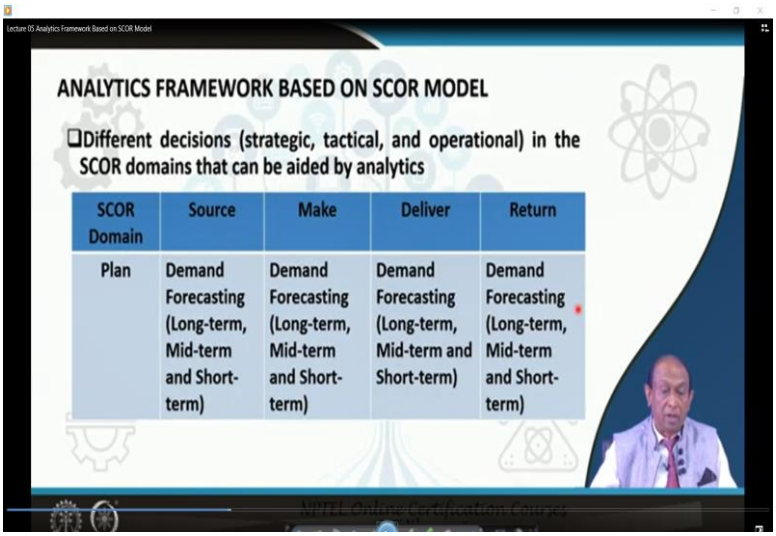

Now, if we look at the different classifications that are being done by the SCOR model, under the planning phase, what we are mainly concentrating on is demand forecasting. Demand forecasting on a long term, medium term and short term basis. In the make phase also, demand forecasting. So demand forecasting is present at all times corresponding to sourcing, make phase, deliver phase, return phase.

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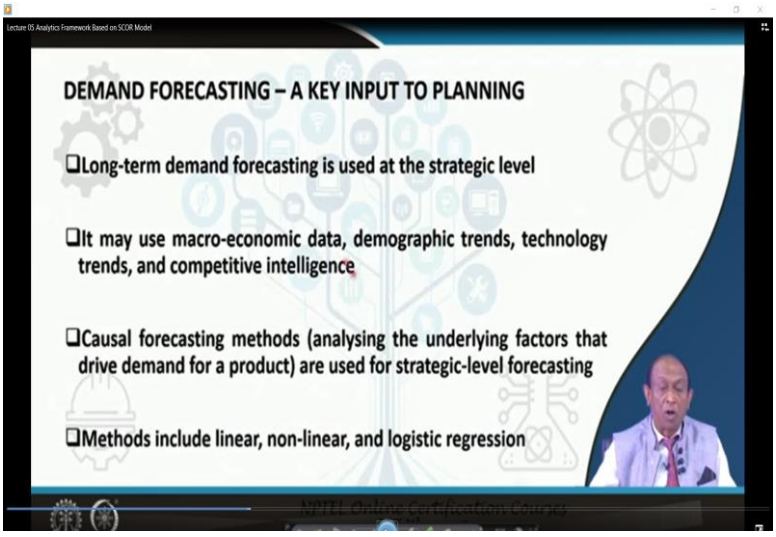

So let us look at something, what does this demand forecasting as a key input to planning is mainly dealing with. Long term demand forecasting is normally applicable for strategic level

decisions. And in long term demand forecasting, we may use macro-economic data, demographic trends, technology trends and competitive intelligence.

Mostly multiple regulation analysis is a technique that is used. Also causal forecasting methods, analyzing the underlying factors that drive demand for a product are used at this level. And methods include both, linear and non-linear modelling as well as logistics regression techniques.

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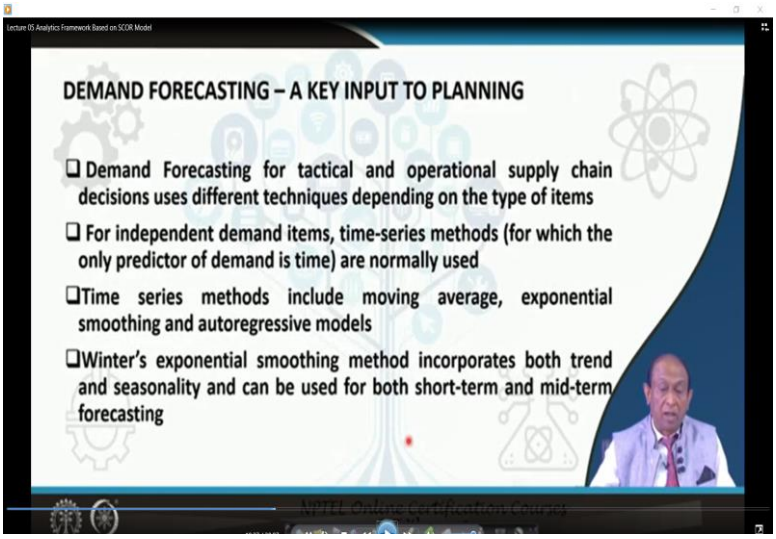

Demand forecasting for tactical and operational supply chain decisions uses different techniques depending on the type of items that we are dealing with. For independent demand type items, time series methods for which the only predictor of demand is time is normally used.

And time series methods include moving average, exponential smoothing, autoregressive models and in here we have to keep in mind that exponential smoothing can be simple as well as double exponential smoothing. Because simple exponential smoothing models cannot take care of the trends in the data. It lags behind this trend. So double exponential smoothing methods are used where there is random fluctuations and along with that there is some either upward trend or a downward trend.

Winter's exponential smoothing method incorporates both trend as well as seasonality and can be used for short term and mid-term forecasting

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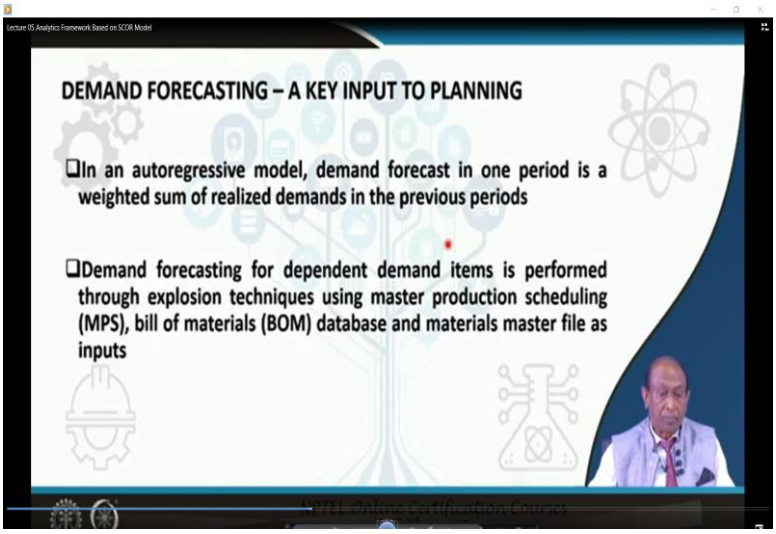

In an auto regressive model, the demand forecast in one period is basically a weighted sum of the realized demands in the previous periods Demand forecasting for dependent demand items is performed through explosion techniques using master production scheduling, bill of materials database and materials master file as inputs.

Now this particular technique, has already been taught to you in your productional operations management course but later on, in some subsequent modules, we will deal in details about how forecasting for dependent demand items is carried out.

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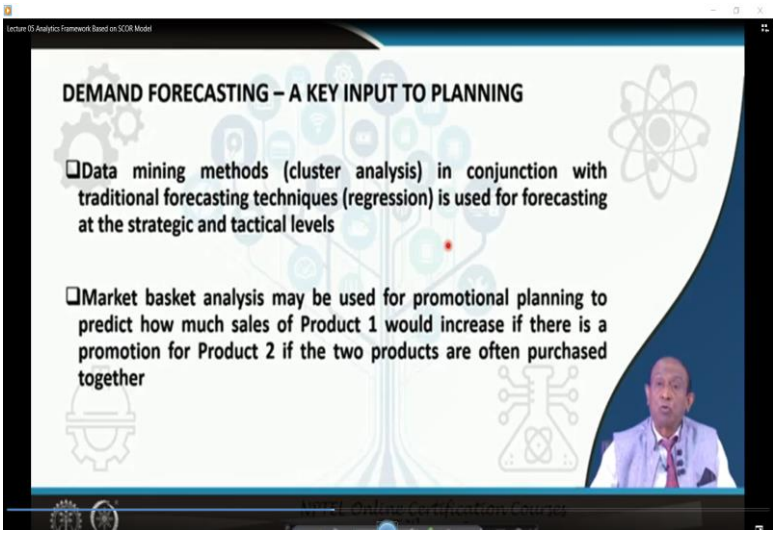

Data mining methods particularly cluster analysis in conjunction with traditional forecasting techniques. For example regression is used for forecasting at the strategic as well as tactical levels. For example, popularly used term like say market basket analysis or it is RSM analysis maybe used for promotional planning to predict say how much of sales of product 1 would

increase if there is a promotion for product 2 when these 2 products are often purchased together. Market basket analysis also will be dealt in, in subsequent modules.

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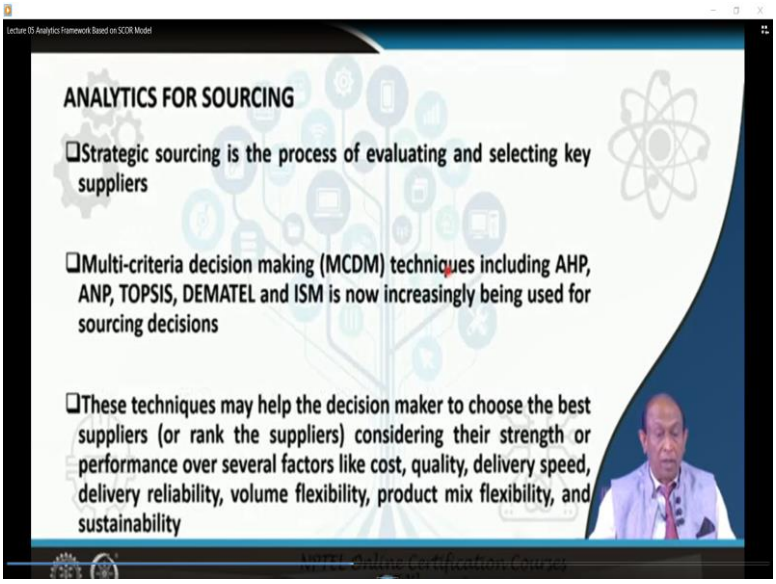

Now let us look into the application of analytics for sourcing. Strategic sourcing is the process of evaluating and selecting key suppliers. In the supplier selection module, which is the next module we will be basically dealing with the different methods and techniques which are used for selecting suppliers and their evaluation.

And particularly, in today's competitive world, multi criteria decision making techniques including analytic hierarchy process which is known as AHP, analytic network processing known as ANP, TOPSIS, DEMATEL and ISM is increasingly being used for sourcing decisions. Some of these MCDM techniques, we would like to cover in our subsequent modules.

These techniques may help the decision maker to choose the best suppliers or rank the suppliers considering their strength or performance over several factors like cost, quality, delivery speed, delivery reliability, volume flexibility, product mix flexibility and sustainability. So multi criteria decision making is basically a technique where we can select the best alternative or rank several alternatives, considering different such criteria together. Overall, when you consider all the criteria together, what is the best possible alternative. So which is the best supplier when we are basically trying to look into various such category or criteria.

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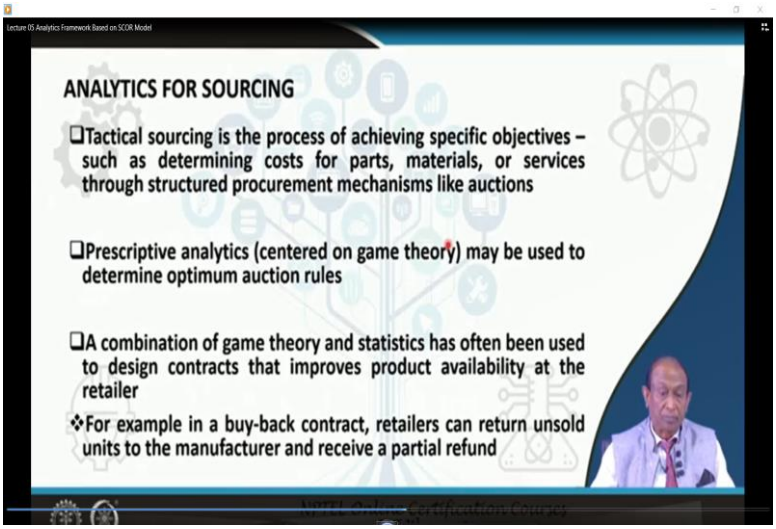

Tactical sourcing is the process of achieving specific objectives such as determining costs of parts, materials or services through structured procurement mechanisms like auctions. In here, prescriptive analytics, particularly is a game theory maybe used to determine optimum auction rules.

A combination of game theory and statistics has often been used to design contracts that improves product availability at the retailer's end. For example, in a buy back contract, the retailers can return unsold units to the manufacturer and receive a partial refund. So design of these contracts are normally covered in any of the traditional supply management courses.

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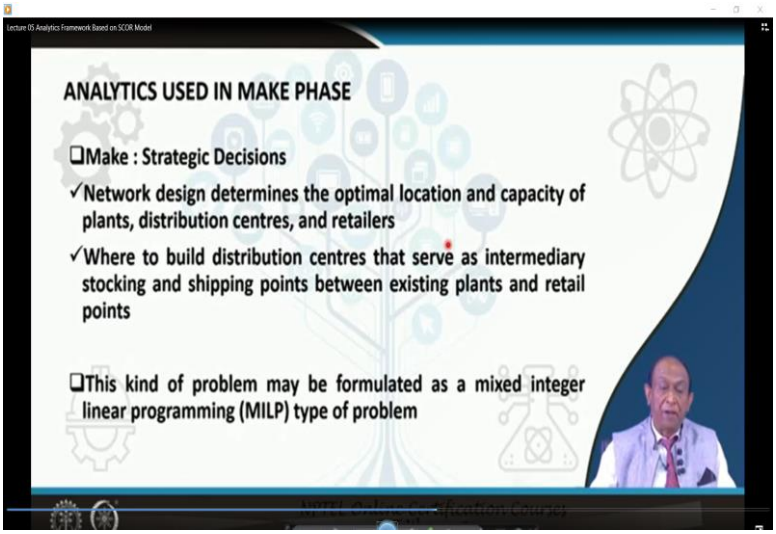

In the make phase, if you look at the strategic decisions where analytics play a major role, can be illustrated through the network design. Network design determines the optimal location and

capacity of plants, distribution centers and retailers. Where to build distribution centers that serve as intermediate stocking and shipping points between existing plants and retail points.

This kind of problem may be formulated as a mixed integer linear programming type of problem and we will be illustrating one such problem in our next module.

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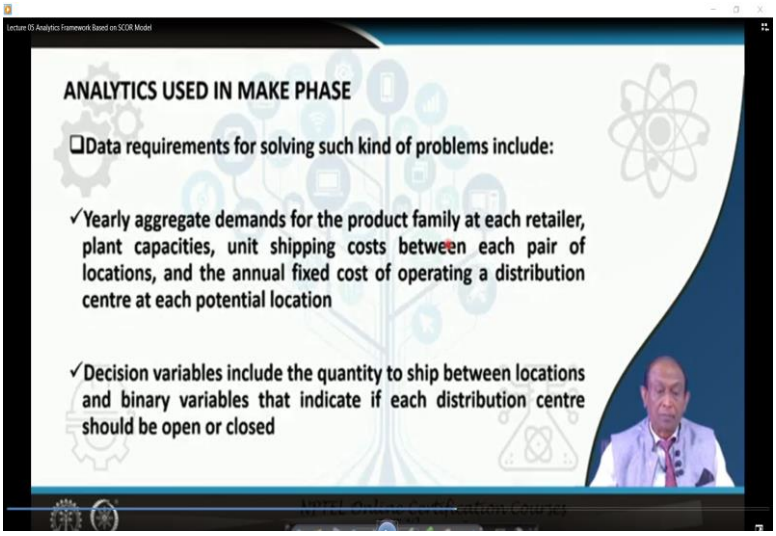

Data requirements for solving such kind of problems include. Yearly aggregate demands for the product family at each retailer, plant capacities, unit shipping costs between each pair of locations and the annual fixed costs of operating a distribution center at each of these potential locations. Here, the decision variables include the quantity to ship between locations and binary variables that indicate if each distribution center should be open or closed.

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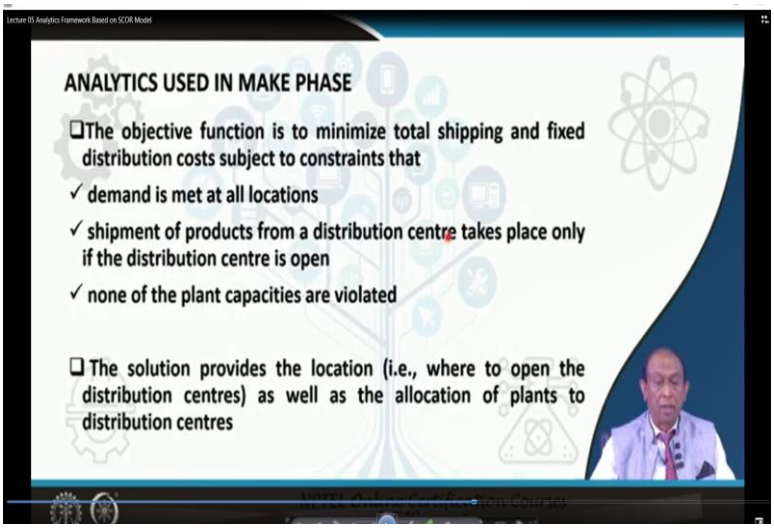

Analytics used in make phase, if we go into the details, for such kind of problem, the objective function is basically to minimize the total shipping and fixed distribution cost subject to the

constraints that demand is to be satisfied at all locations. Shipment of products from a distribution center to take place only if the distribution center is open.

I had already said that this is going to be a binary variable. So if the distribution center is open, then only the question of shipment of products from those locations is under question. None of the plant capacities should be violated. So these are the difficult different constraints and the objective function is to minimize the total shipping and fixed distribution.

This solution provides the location that is where to open the distribution centers as well as the allocation of plants to distribution centers.

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Variants of this type of mixed integer linear programming problem include multiple products, transportation capacities between location, multi-year planning horizon, demand uncertainty, supply uncertainty and reverse flows, for example the collection of used products for recycling and remanufacturing.

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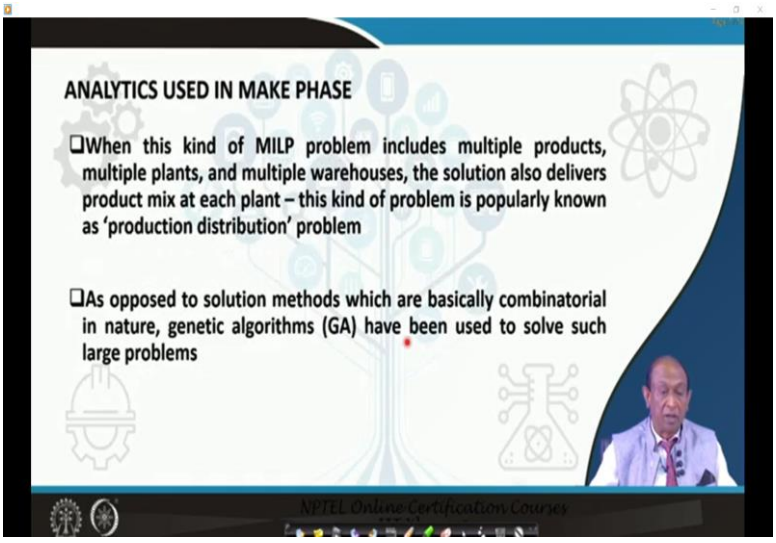

When this kind of mixed integer linear programming type of problem includes multiple products, multiple plants and multiple warehouses, the solution also delivers product mix at each plant. This kind of problem is popularly known as production distribution problem. We will be illustrating one such kind of problem in subsequent modules. As opposed to solution methods which are basically combinatorial in nature, genetic algorithms have been used widely to solve such large problems.

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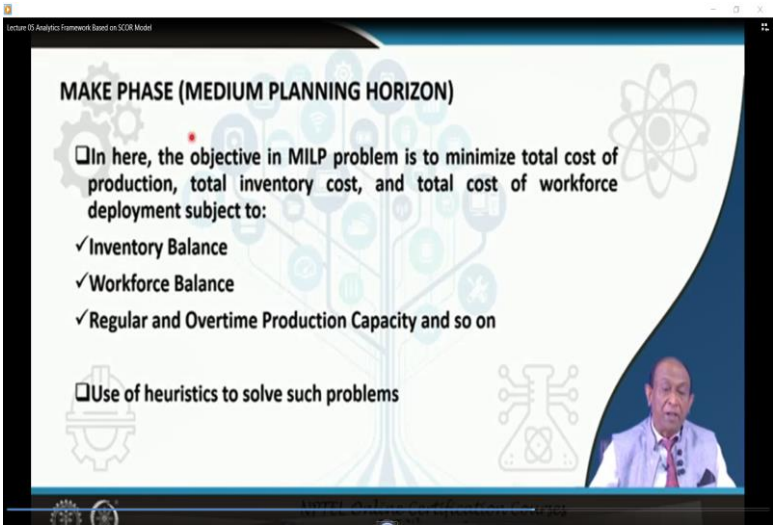

Make phase, when we look at the medium planning horizon, the objective in such kind of MILP problem is to minimize total cost of production, total inventory cost and total cost of workforce deployment subject to inventory balance that is opening inventory plus the production or the procurement that has taken place during that period minus the consumption is going to give you the end inventory or the final inventory.

Similarly, you consider workforce balance equations and also you can consider regular and overtime production capacity and this should not be violated and so on. So this is a typical, you know, aggregate planning type of problem where in lots of heuristics have been developed to solve such effective, to such solve such problems with effectiveness. May not give you heuristic may not give you an optimal solution but it will give you an effective solution.

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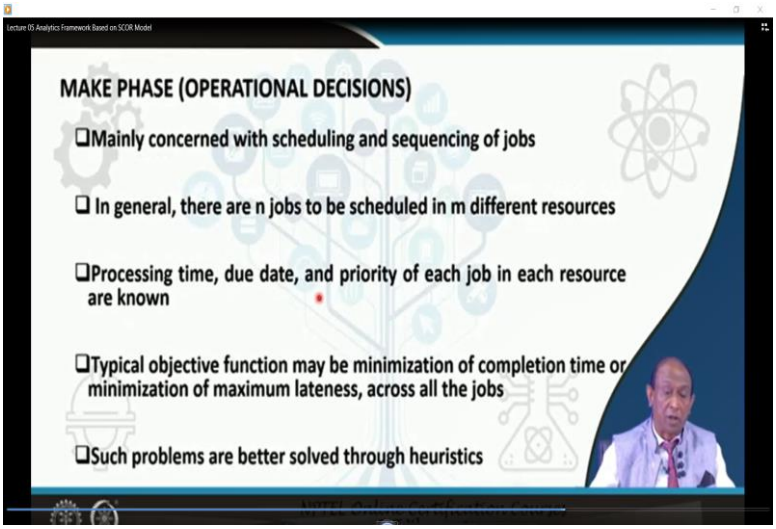

During the operational phase, we are mainly concerned with scheduling and sequencing of jobs. In general, in a sequencing problem or a scheduling problem, there are n jobs to be scheduled in m different resources. The processing time, the due date, and priority of each job in each resource are known. And the typical objective function maybe minimization of completion time or minimization of maximum lateness across all the jobs. Such problems are also better solved through heuristics.

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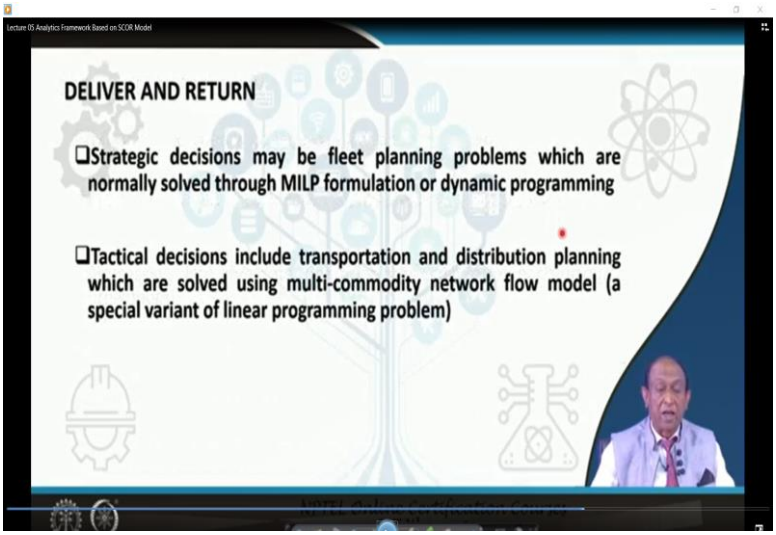

Strategic decisions under the deliver and return phase maybe say fleet planning problems which are normally solved through mixed integer linear programming formulation or dynamic programming. Tactical decisions include transportation and distribution planning which are solved using multi commodity network flow model and this is nothing but a special variant of linear programming problem which is normally covered in a typical operations research course.

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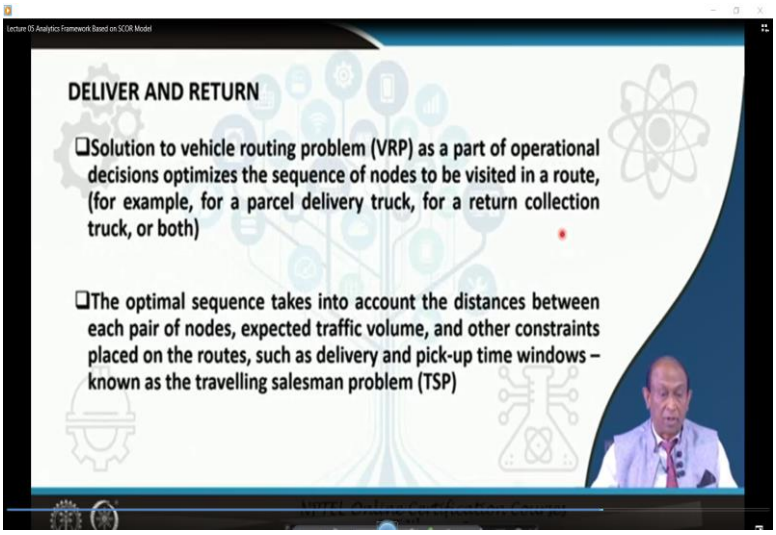

In the deliver and return phase, solutions to vehicle routing problem as part of operational decisions, herein we optimize the sequence of nodes to be visited in a route. For example, for a parcel delivery truck, for a return collection or both.

Here, the optimal sequence takes into account the distances between each pair of nodes, the expected traffic volume and other constraints placed on the routes such as delivery and pick up

time windows and similar such constraints. These type of problems are known as travelling salesman problem or a TSP.

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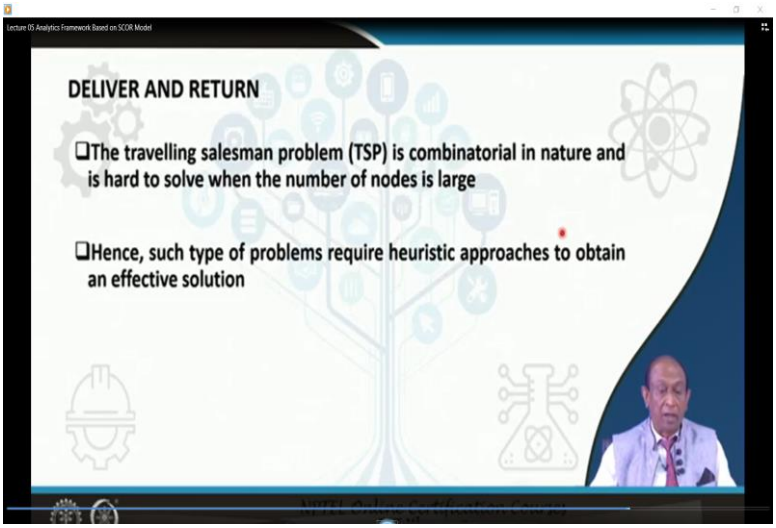

The travelling salesman problem is basically a derivative of mixed integer linear programming type of problem. It is combinatorial in nature and this very difficult to solve when the number of nodes is large. Hence, such types of problems require heuristic approaches to obtain and effective solution.

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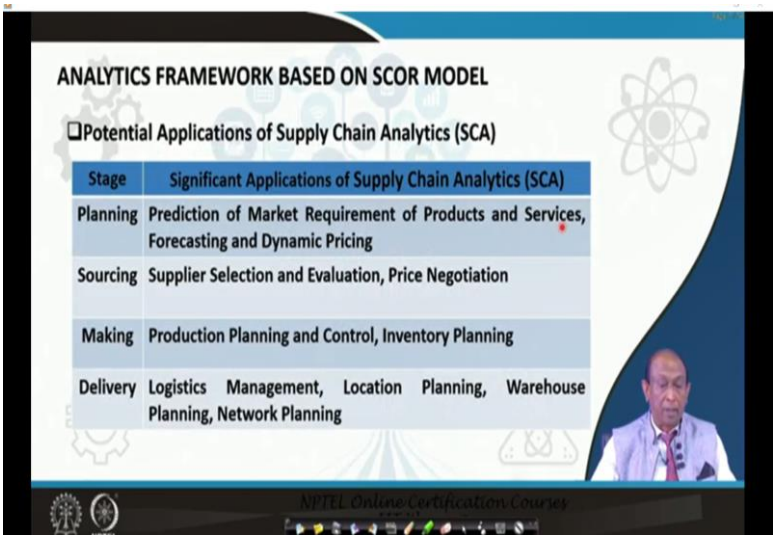

So now, let us summarize, with respect to the potential applications of supply chain analytics in different stages of the SCOR model. In the planning stage, what we are saying that, we are mainly dealing with prediction of market requirement of products and services, forecasting and also sometimes we are confronted with the problem of finding out pricing dynamically dynamic

pricing. In the sourcing stage, we cover supplier selection and evaluation as well as price negotiation.

In the make phase, production planning and control, inventory planning are the primary activities where analytics can play a great role. In the delivery phase, logistics management, location planning, warehouse planning, network planning, they are the primary activities being carried out in the delivery stage.

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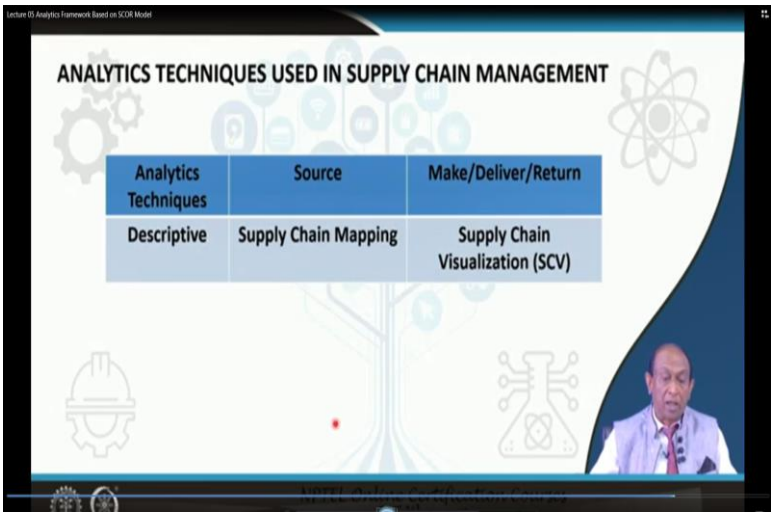

So, in our last, previous lecture, we had talked about different analytic techniques wherein we said that descriptive analytics, we described what is there in descriptive analytics. So what is happening and in the sourcing phase, we mainly do supply chain mapping. In the make deliver and return phase, under descriptive analytics, we are basically concerned with supply chain visualization.

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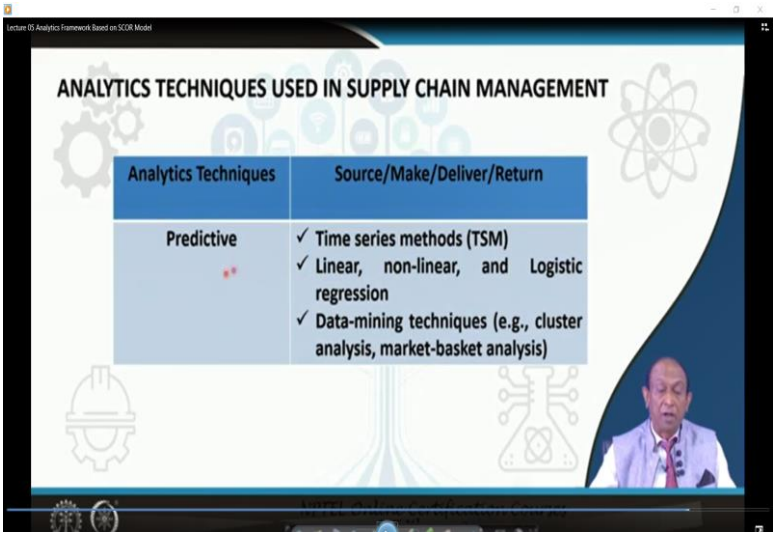

In the predictive analytics application, we basically see applications of time series methods, linear, non-linear and logistics regression and data mining techniques including cluster analysis and market basket analysis. During this sourcing make, deliver, return and all the stages and this is a domain of predictive analytics.

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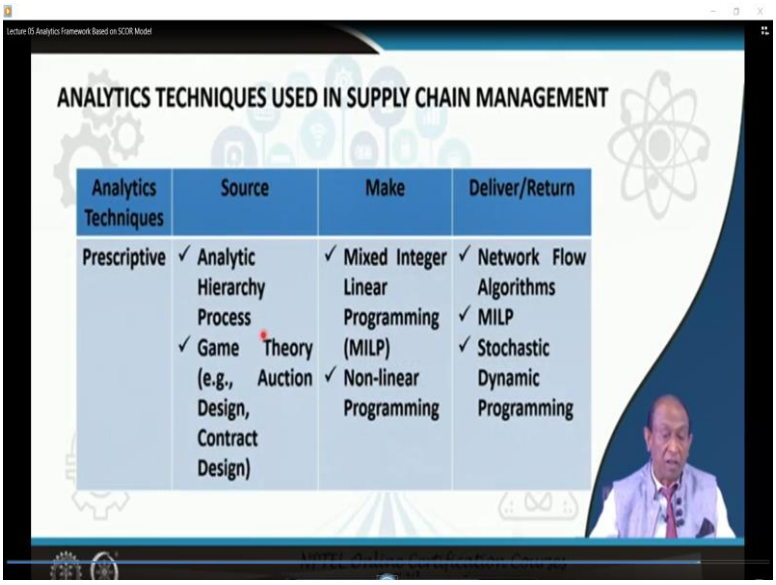

Prescriptive analytics is being widely used in supply chain management and during all these stages, say sourcing, we use multi criteria decision making. AHP is widely used, then we use a game theory. For example game theory and statistical application have being widely used for auction design, contract design.

In the next phase, we basically talk about mixed integer linear programming applications as well as non-linear programming applications. Although, practitioners basically, if the objective function is non-linear, they try to solve those kind of problems using piece wise linear programming, which can be solved through, very easily through of the self-available software.

And in the deliver and return phase, we basically find applications of network flow algorithms, MILP, stochastic dynamic programming. So you see, in order to be a very good specialist in the application of such techniques in supply chain or supply network, one needs to have a solid background in statistics and operations research.

I would also associated with that, the other day I had mentioned that one should have a tremendous domain knowledge. Without domain knowledge, without knowing the business processes, only mathematical techniques will not help you to give a solution. You have to

basically frame models as simple as possible so that the model output can be explained to its users in the most simple terms.

You know, so everybody can understand how you have developed that model, how you have constructed the model, what are the results that are coming out of that model, the managerial interpretation is very important and the implications of that in real life has got lot of you know importance, so that this kind of application or techniques can be made more popular.

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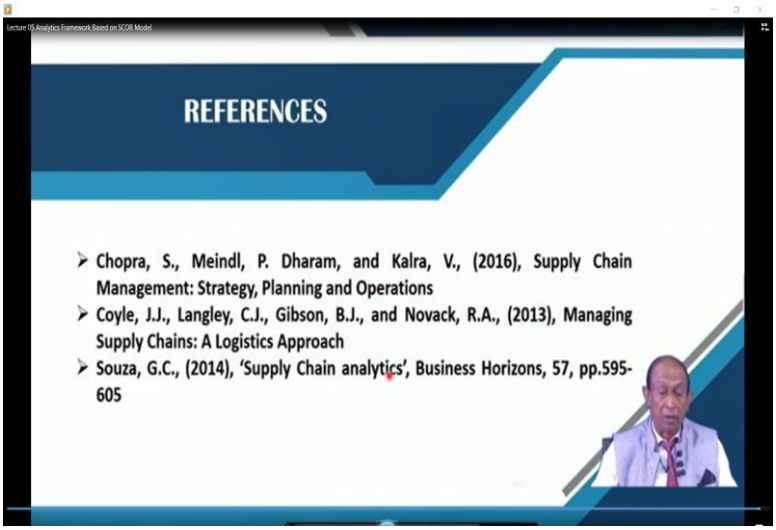

Thank you all for concentrating and listening to this particular module. We will be dealing with different configurations of the supply chain network in our next module. Thank you all.