Production and Operation Management
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Lecture 16
Inventory Planning and Control

Welcome friends, so, now, we are entering into the fourth week of this course on production operations management. In last two weeks, we discussed in detail about forecasting issues, we discuss the need of forecasting, we discuss what are the various types of methods of forecasting, we discuss in detail about two methods, one is time series methods and the second is regression analysis.

Regression analysis we discussed as part of causal methods. Causal methods we discuss in last class are of two types one is regression and another is econometric methods. Many a times econometric methods are also very useful for the forecasting, but these are you can say extension of our regression analysis. How these are the extension of our regression analysis? Sometime it is possible that the independent factor which we are considering for determining the forecast is also a function of to some extent of that dependent variable.

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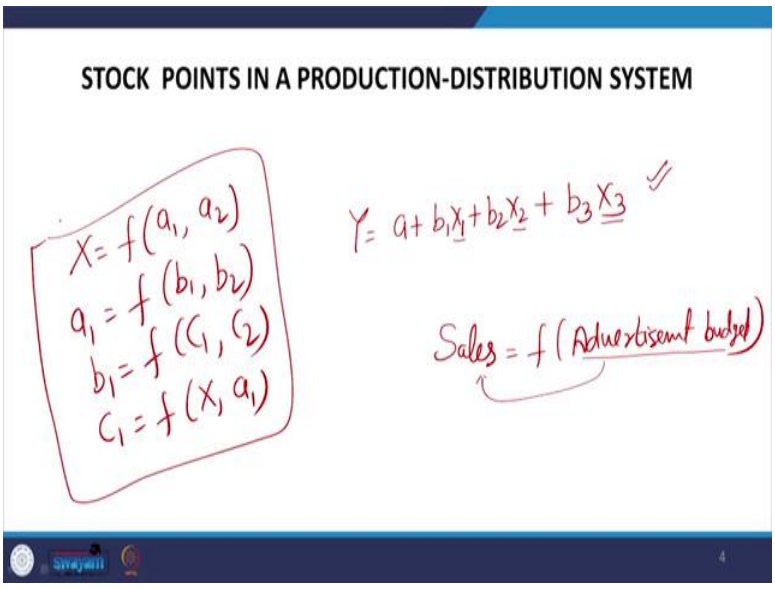

For an example, if I consider that some of the sales is a function of advertisement expenses. Now, in this case it is quite possible that advertisement budget is also a part of, is getting affected because of sales. So, here we use a system of simultaneous equations, where all

those relationships can be proved simultaneously. So, one equation is not sufficient sometime to give you the real picture, because there may be some kind of interdependency also.

Here, if you see in our multiple regression analysis, Y equals to a plus b1x1 plus b2x2 plus b3 x3. Now, here what we are assuming which is important and we did not discuss in over that session that all x1 x2 x3 which are the causal factors, these are totally exclusive, there is no interdependence between x1 x2 x3 and there is no dependence of x1 x2 x3 on Y. So, that way Y is dependent on x1 x2 x3 because of this relationship, but vice versa is not true. Vice versa is not true that x1 is not at all dependent on Y, x2 at all not dependent on Y, x3 at all not dependent on Y.

So, when these are totally independent of Y and in between also there is no interdependence, this equation holds good, but many a times it is not possible that there is no relation between these independent factors. In economics, most of the factors are affecting each other, more you purchase, more you purchase your cost of living index increases and cost of living index increasing that is an indicator that you are purchasing more and more things.

So, there is an interdependence between purchase of your products and cost of living index. So, now if you say that cost of living index is only affecting the demand, but demand is also affecting the cost of living index. So, that type of interdependence how to model that, that is possible with the help of econometric methods where we have three four simultaneously like factor x equals to f, two factors are there a1, a2 then a1 is dependent on two more factors b1 b2.

b1 is a factor, which may depend on c1, c2 and c1 may be a factor, which is depending on x and a. So, that type of simultaneous equation, this type of modeling is known as econometric modeling. So, that is a more complicated issue, we discuss these type of forecasting methods in our classes of economics, sometime in the cases of statistical classes also we discuss this type of simultaneous equations handling. So, many times more number of simultaneous equations are developed and what will be the nature of these functions, that is also unknown, it may not be a linear relationship it may be a nonlinear relationship also.

So, if you increase the complexity of these equations, so the solution process will also incorporate that much of complexity. So, we are not going to discuss this anymore further, but just to give you an idea that how there may be a lot of interdependencies between the factors, which we did not consider in our last session of causal method. So, it was important

to discuss this aspect that whenever interdependencies are there econometric methods are used to handle such a type of situation. Now, in this particular case, we are not going to discuss the forecasting the todays session is more related to inventory management and development of various inventory models.

Inventory is a very important and crucial decision for the organization. In fact, if we see in a smaller organization, the purchase manager or the owner of the organization take a lot of intuitive decisions, but those intuitive decisions are only good for a small organization. When we are having a large organization, where the number of components which are to be managed, their number is also very large in that particular situation, this intuitive abilities of purchase manager are not sufficient.

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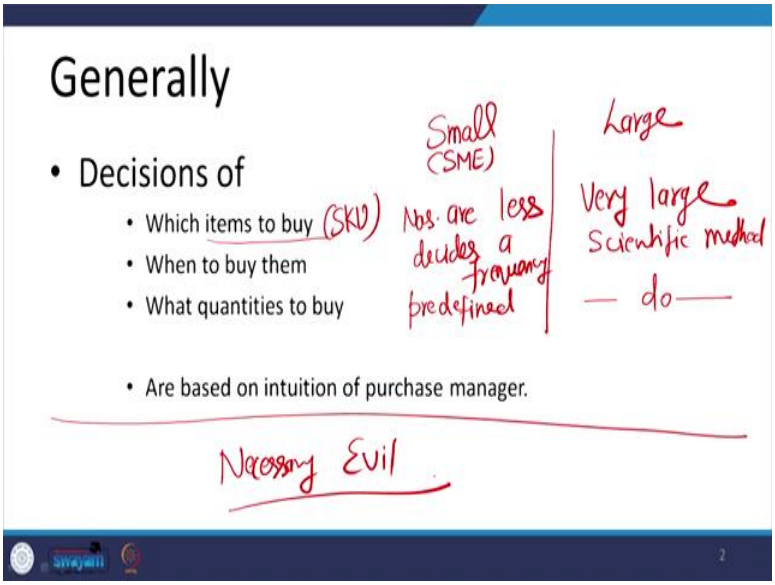

We take decisions with respect to our inventory management which items to buy in a small organization or you can say SME, and this is large, so, which items to buy, so numbers are less but it is really, really very large in case of a large organization, multi (corp) national corporations, these numbers are very large, because our SKUs stock keeping units are increasing day by day. When to buy them? Now in the case of small medium enterprises, this purchase manager on its own decides a frequency.

But here we have to go for a scientific method that when to purchase? If we do not have that scientific method, some time you will have more inventory with you and sometimes you will be running out of stock for some of the material. Both these things are not desirable. What quantities to buy? So, here you have a predefined or predetermined quantity, that every time

whenever you are ordering, you order 10 units, 50 units, 100 units depending upon the size of your organization. But here in the large organization, it also requires a scientific approach for quantities to buy, how much quantity you want to buy, that has to be scientifically determined, because inventory is a necessary evil.

What does it mean? That we want to keep inventory because it is required for a smooth production. It is required to fulfill the demand of the customers on a fluctuating basis. But at the same time, if you are not keeping proper inventory, there are possibilities that it may eat in your all the profit or it may create a lot of dissatisfaction among the customers. So, you have to keep the inventory that is the necessity, but if you are not keeping the inventory properly, it can be a very dangerous thing for your organization. So, for that purpose, we say that inventory is a necessary evil.

Now in a large organization, it is a difficult thing to determine what are the symptoms of mismanaged inventory, but still we need to determine, we need to understand whether we are having a proper system of inventory management or not. Because, unless until you know our inventory system is functioning properly or not how will you manage it? So, though it is a difficult thing, but still, you can have a small checklist with you, which can help you in determining the status of inventory management in your organization.

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Now, some of the points which we are discussing here, the point number one is total amount of inventory rises faster than the growth of sales. So, the inventory value, inventory value is rising faster than the sales growth, it means, there is a continuous accumulation of items in

your stocks. So, that is a very dangerous thing, because sales are not increasing at that ratio and your inventory is accumulating at that ratio. It means whatever you are able to generate because of your sales growth, that all is going into inventory accumulation this is not going to increase the profitability of your organization, you are creating a Dead Pool for your organization. So, that is one symptom of mismanaged inventory if inventory amount is rising faster than the sales growth.

The second is, is stockouts of items occur, customer is coming, but you check your stock and it is not there in your store, causing interruptions in production or delayed deliveries to the customer. So, if a production interruption is happening, this means, you are not able to use your productivity your machines time up to the maximum availability or delayed deliveries to the customers may raise some kind of penalty, if there is a penalty clause. Otherwise, it is simply going to result into customer dissatisfaction. So, stockouts are possible and stockouts may result in these two things.

Then third is clerical costs for procuring, expediting and maintaining inventories become too high. Whenever you are giving order, there are certain clerical costs associated with that, these are related to procurement, you have to chase the supplies and then you have to maintain inventory in your stock. So, you need to keep storekeepers, you need to have some space etcetera. So, if these costs are also increasing on a regular basis, it is again a symptom of mismanaged inventory.

There is too much quantity in stock for some items and too little for others. So, because you are taking decisions on the basis of your intuition and it is possible that you have excessively stocked some items and for others, there are stockouts. So, that type of distribution where you have piled up a stock of some items and stockouts for others, that also means it is a case of mismanaged inventory. The other symptom is items are missing or misplaced. And spoilers and obsolescence rates are too high means you do not have proper system of warehousing, how to keep items in the store.

So this is resulting into missing, misplacing or spoilers. Because you do not have proper material handling equipments, you do not have proper racks and therefore, the spoilers misplacing or all these missing things are happening or because some items are stored in the last rack and you are not able to track the availability of those items, and by the time you see those items, they have lost their shelf life. So, all these things are resulting into again,

mismanaged inventories. So, when you are seeing that all these things are happening regularly in your organization, it is a good symptom that you require a proper scientific inventory management.

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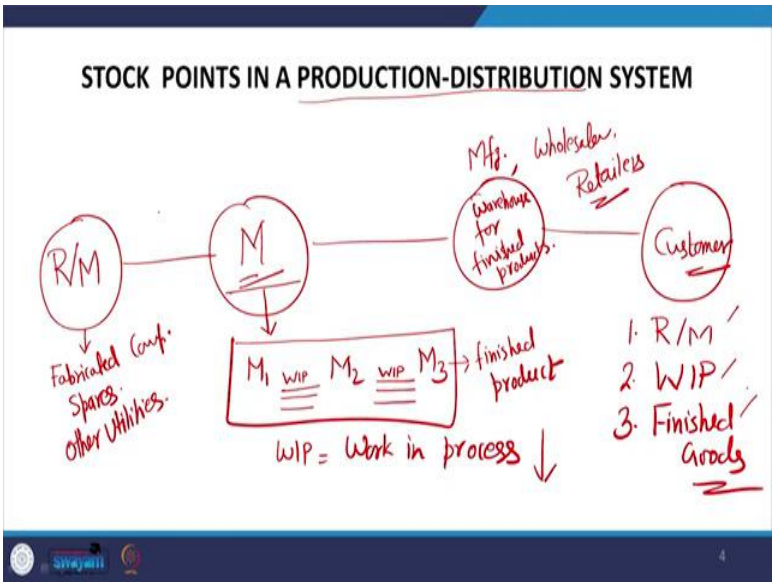

Now, in our organization, when I am saying organization so, I am including production and distribution system both. Now there are various points where we stock items in our production and distribution system. Like if, I am a manufacturer. So, first I am going to purchase raw material So, I am going to stock a lot of raw material with me and in this raw material is the fabricated component spares, other utilities, etcetera, all these things are the part of these raw material.

So, I require a raw material stocking place in my factory then comes the manufacturing stage. During this manufacturing so, various machines are there and from M1, M2 M3, these are the machines. So now at these places you have items which are stocked intermediately and these are known as work in process items. So, you have lot of WIP, that is work in process. So, WIPs are also there as part of our inventory management system, we want to keep minimum WIPs.

So that our cost of in process material is also as low as possible. Now, once the items have passed from this M3 stage, here you get the finished product. So, this is the warehouse for finished products. Now these warehouses are available at multiple location, these warehouses may be at the manufacturer. These warehouses will be at the wholesaler and these warehouses may be at the retailers end also. So, in my distribution system, there will be

warehouses at the factory, there will be warehouses at different locations which are controlled by wholesalers. And finally, at the last mile delivery level, you have warehouses owned by the retailers. And finally, the customer is there who also is talks some item in anticipation of demand.

So, this is the various stock points in my production distribution system right from the raw material procurement by the organization. So, we have one warehouse, one complete system of stocking the item for the raw materials, different types of raw materials we use, and where I am also saying that the various types of spares, sub-assemblies etcetera all these are the part of my incoming material to the manufacturing facility. Then in the manufacturing facility you have work in process materials were incremental value addition is going on.

And once the value addition process is completed, you have finished goods and then you require a storage facility for those finished goods. So, these three important stages are there. One is raw material. Second is WIP and third is finished goods, these three types of items are there and here no value addition, intermediate value addition and full value addition that you can understand in terms of a value chain.

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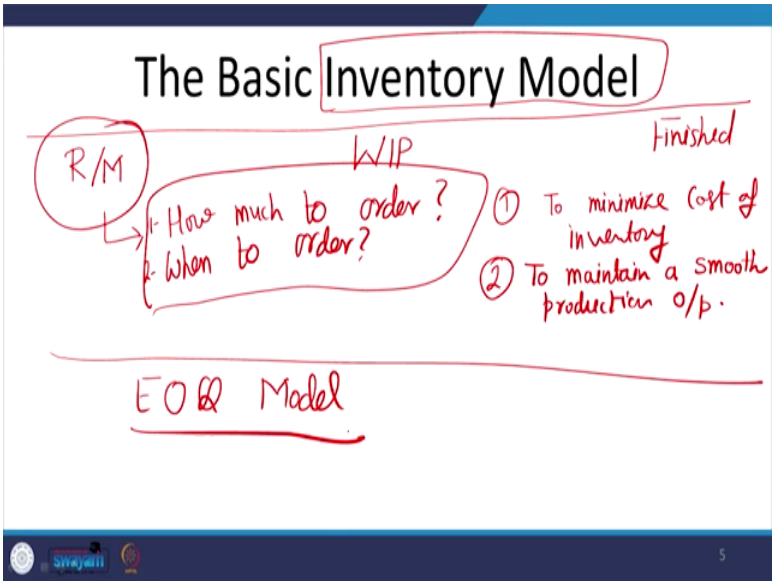

Now in our discussion of inventory management, we are primarily going to discuss, as we just discussed that there are three stages raw material, WIP and finished goods. So, our primary discussion of basic inventory model will start from this raw material inventory management and slowly we will move to discuss WIP and finished good inventory

management also but, at the moment, we are starting from the simple most item that is the raw material we have no value addition has taken place.

Now, when we are giving a order for raw material, when we are giving order for raw material or some component, what important questions you need to answer that is going to decide the development of my inventory model. So, we decide, we decide or we think of two particular issues. One issue is how much to order and second is when to order, these are the two important things which are crux of any inventory model. How much to order and when to order? If we are able to find a good answer to these two things, we will be able to minimize, our objective is to minimize cost of inventory that is number one and at the same time, the second objective is to maintain a smooth production output.

These are the two important objectives of my inventory system. I want to minimize the cost of inventory but at the same time I do not want to compromise with my production output. So, both these things can be easily solved, if I answer these two questions. So, I request students that whenever we are talking of inventory management, it means we are interested in these two things, how much to order and when to order.

So, we need to decide a frequency of ordering and we need to decide a quantity how much to order. Now, the development of mathematical model for this particular purpose, it starts with basic inventory model. Now in the basic inventory model which is also known as EOQ model. EOQ stands for Economic Order Quantity model where we will decide a quantity of order which is going to minimize the overall cost of inventory management.

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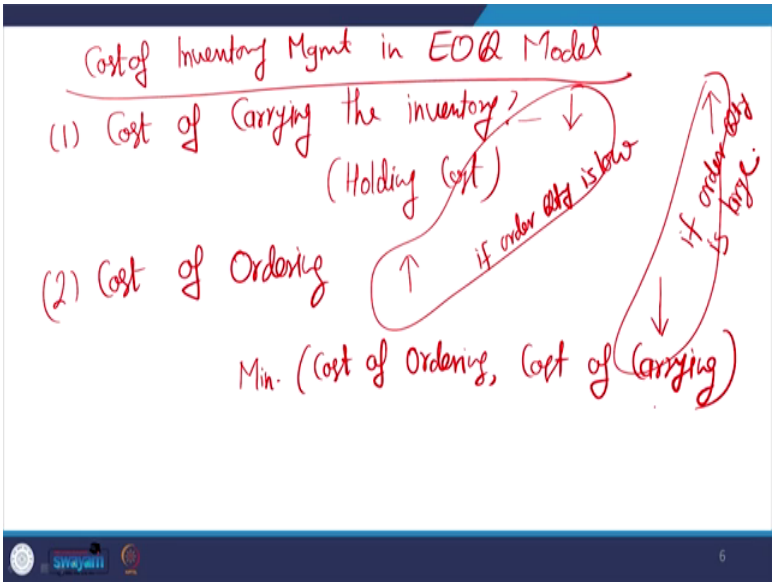

Now, in this particular case, first important thing is we need to see what are the different types of cost of inventory management in EOQ model. What are the different types of cost, we are going to consider in basic EOQ model. Now, two types of cost, we are going to consider in basic inventory management model using EOQ. One is cost of carrying the inventory. Now what is it?

When we are keeping inventory of items with us, we are incurring some cost on it you are putting those items in some warehouse, so you are paying rent of that warehouse, you have done some insurance of those items. So, those insurance charges are there, you have blocked your capital on holding that inventory. So you are losing interest on that capital and maybe some spoilage has also taken place. So all these are the costs which are part of your carrying cost. In literature you may also find another name for this carrying costs that is Holding Cost.

So, that is another name of the carrying cost. The second cost is cost of ordering. Now in the cost of ordering, this cost is a cost which we incur whenever you give some order. So, the cost of loading, unloading, cost of placing the order all those clerical costs are the part of cost of ordering, mostly it is loading, unloading kind of cost which is in the part of cost of ordering. Now, when we are giving order of very small quantities, so, your cost of carrying the inventory will be low.

But each time you have to handle that order, so your cost of ordering will increase if order quantity is low or if you give order quantity of a higher size in that case you will have more items in your inventory at a time. So, your inventory carrying cost will increase, but you will

have fewer orders in a year because every time now, you are giving order of a larger quantity. So, you will not give many orders you will give less orders. So, therefore, your cost of ordering will go down.

So, if order quantity is large. So, we want order quantity of that way, which can actually balance these two scenarios, you have 2 scenario, one is order quantity is low. So, in that case, your cost of carrying the inventory is less, but when your order quantity is more, your cost of carrying the inventory is increasing and it is just vice versa it is just reverse to your cost of ordering. So, actually we want to have minimization of cost of ordering and cost of carrying. So, our purpose in this basic inventory management model is to minimize the cost of ordering and cost of carrying.

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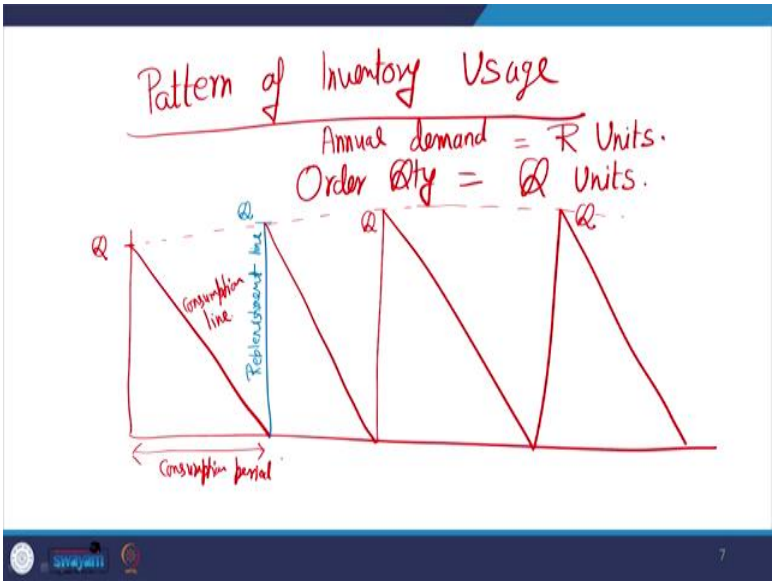

Now, how it will happen let us see that. Now for that purpose first we need to understand the Pattern of Inventory. Now Pattern of Inventory Usage, for this purpose, let us say our annual demand of a particular raw material is R units and each time I am giving an order of Q units my annual demand is R units and each time I am placing order of Q units now what is going to happen for that purpose let us have this graphical representation. So, on day one my year is starting today, on day one, I receive supply of Q items and I will start consuming these Q items. So, this way I will consume my Q items.

Here I am assuming, here I am assuming that I have a constant consumption rate. I have a constant consumption rate therefore, this straight line of consumption is there, this is consumption line. Now, once I have consumed all these items, then I will replenish, then I

will replenish my stocks again and this will again go to original Q level because again a new supply of Q item will come as soon as I finished my original stock of Q. So, this is replenishing of the stock. So, I reach again to this Q level.

As soon as I reach to this Q level again I will start consuming it and again I will completely exhaust the available stock, again I will have this replenishment of my stock and this type of pattern will go. So, you see, this is a saw teeth pattern where every time I am getting Q supply, I start consuming those Q supplies and after some time, the stock will finish and again I will get Q supplies. So, this pattern will go on perpetually and I have to see that how this pattern can be mathematically modeled, so that I can minimize whenever I am getting this Q item, this is incurring me the cost of ordering.

Whenever this period is going on, this is the consumption period. This is the consumption period. So, whenever this consumption period is going on, I am holding the inventory of Q item which is replenished, which is reducing over this period, but from Q to 0 I am reaching in this period again I will get q item. So, slowly, slowly, you see that this kind of saw teeth pattern is going to happen.

So, on the basis of this saw teeth pattern, we will develop a mathematical model so that we can minimize the cost of inventory which is a result of cost of ordering and cost of carrying. So in our next session, we will develop that mathematical model to balance, the cost of ordering and cost of carrying. And this saw teeth pattern will make the basis for our development of various mathematical models related to inventory model. So I request students to understand this model deeply so that we can have more variations of this model in our coming classes. Thank you very much.