Supply Chain Analytics
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Lecture-16
Inventory Management in a Supply Chain

Welcome back, in this course of supply chain analytics, so far we have discussed about various types of forecasting models which we used for taking decision with respect to planning of various activities in the supply chain. In our last session we also started one very important issue in the supply chain that is inventory management. Inventory management is a subject which most of us have studied in the classes of operations management, but inventory management when we study only for a stand, alone, entity.

That inventory management is very different type of inventory management. In case of supply chains where various entities are linked with one another inventory management alone can make or destroy your supply chain decisions. So, it is very important in a supply chain case, that we take very appropriate decisions with respective inventory management. Obviously, the feeding the input for taking decisions with respective inventory is provided by the forecasting.

That is why we discuss forecasting in the beginning of these various decision making activities. Now, we are in to this inventory management, and in operations management class I expect that most of us have already studied, various different types of inventory management models.

Now, we will see here, in this particular course that how we can extend those inventory management models in a supply chain environment. Supply chain environment when I say, it is being characterized by having different types of entities in your supply chain.

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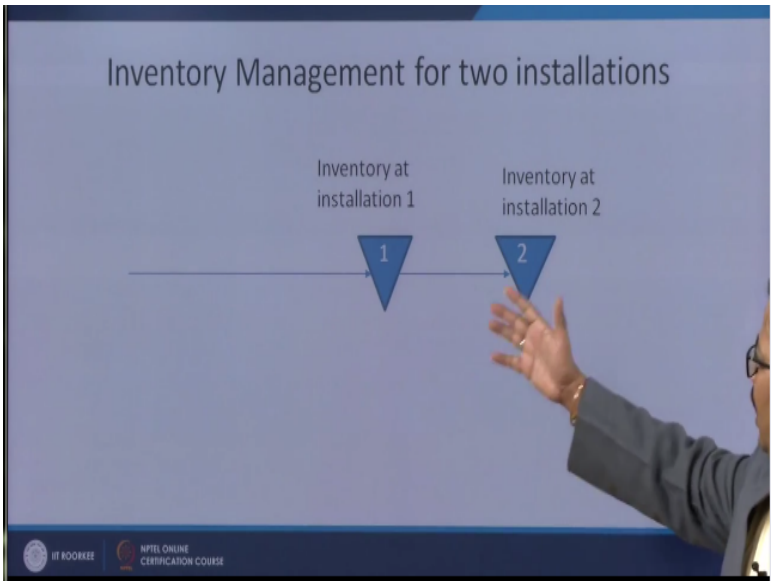

This is a very simple case, we started with in our last session, that here we have 2 installations. In this supply chain we have 2 installations installation 1, and installation 2. In installation 1 you can say can be the wholesaler, installation 2 can be retailer, or installation 1 can be a manufacturer and installation 2 can be a retailer directly. So, just to start the discussion that how do we move from our conventional inventory management where we discuss only a particular installation.

In that case in a conventional system we consider only a particular station and we manage the inventory only for one single entity. Here, if we do that, means if we start managing the inventory separately for these different entities. We will lose the very essence of supply chain management. So, therefore it is important that we should consider, that whatever decisions are taken.

This should be taken in the interest of entire supply chain. Right from the day 1 when we started this course, we are talking continuously about (()) (04:01) about taking decision where we can take the interest of entire supply chain. And, therefore we will use principles of or the formulas or the models developed for single installations. But, here we will extend them in a supply chain environment.

So, to start that case, we are taking only 2 installations as I just explained. Now, in case of this particular model we can understand, that there are different type of relations between 1 and 2. But, one thing is very interesting, we all can easily appreciate that if 1 is a wholesaler, 2 is a retailer. If 1 is a manufacturer, 2 is a retailer, if 1 is a supplier of some type of raw material, 2 may be the manufacturer.

So, what I am trying to say that as we move from this side to this side in a supply chain. As I am moving from left to right in a supply chain. I am adding more value to my product, and therefore many times supply chains are also known as value chains. Because, with our formal movement with our movement from left to right we are adding value to our products.

And, therefore supply chains are the value chains and as I am adding value to my product from left to right the correspondingly the unit cost of the product also increases, because of the value addition. So, if you remember in our conventional model of inventory management. We use to have 2 important very well cost.

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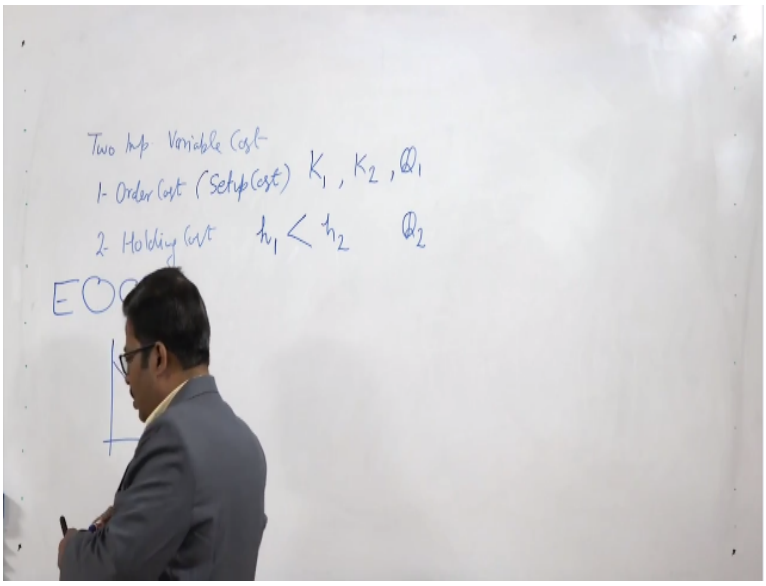

And, you can recall that these 2 important cost are one is order cost, and the second is holding cost. These are the 2 important cost, which we consider in our most popular inventory management model that is EOQ model. That is Economic Order Quantity Model. In that EOQ model we consider these 2 types of cost. Now, the holding cost, the I will like to emphasise on.

The holding cost is that cost when you are keeping inventory with you, you incur some type of cost on keeping that inventory.

And, that cost may come from variety of sources. For keeping some items in your stock, you have taken a warehouse on rent. So, that rent which you are paying for keeping the rent may go for this holding cost. You are paying for the security of the item, some type of insurance premium. That insurance premium will also be the part of the holding cost. Then, there will be some kind of opportunity cost also.

You have blogged your capital in keeping the inventory, and as a result of that you are losing some other opportunities of using that capital, so that is also added in to the holding cost. So, holding cost may come from variety of sources. And, therefore holding cost is always you must have learned in operation management classes. That holding cost is always represented as a % of the total material cost. The cost of the material which you are buying for which you are keeping the inventory.

So, it is always represented as a % of that material cost. The order cost or in some literature you will also find the name setup cost. So, the setup cost or the order cost. This setup cost results because of a your receiving the order, whenever you given order, so the setup cost will come, because there will be some kind of loading, unloading, some kind of communication involved.

So, these are the order cost, whenever in a plant you are working, and whenever you are changing from one product to another product. So, you need to change your tools, so, you need to change your dyes, and all those things. And, as a result of that we call it setup cost. So, like just to explain these 2 costs more clearly to you. Let us take an example in that example I want to drink cold drink after my dinner daily.

And there are 2 possibilities. One possibility that I take my scooter and after dinner daily I go to a general store, take one cold drink. So, that is one way of keeping the known inventory. So, whenever I require on a daily basis I go to a general store take a cold drink. On the other hand I can also do that in one go I can purchase the entire carrot of the cold drinks. Maybe of 12, maybe

of 20, and then I consume these cold drinks one by one daily, and I need not to visit that general store again and again on the daily basis. For next 10, 12, or 15, 20 days.

So, in that case going to that general store and coming back, the amount of fuel that I am consuming that will go to the order cost. And, since I am not keeping any cold drink in my stock, so holding cost is absolutely 0 in this case. On the second criteria, when I am purchasing the entire carrot for the cold drink, for let us say one month stock. So, I need to go to that general store, to purchase cold drink only once.

So, my ordering cost has reduced substantial here. I am ping the ordering cost only once, and the holding cost has increased tremendously now. Because, I have kept the stock of 30 cold drinks with me in one go. So, I have paid some 200 rupees or like that for that purpose, and for that purpose my 200 rupees is blocked. I cannot use that money for any other activity, and it is also possible that in this leakagement takes place.

Some wear and tear may take place, so I may loss my one cold drink, so that loss will also come in to the holding cost. So, I have to take a call, I have to be and optimum that my ordering cost and holding cost should have some kind of balance, and when I achieve that balance these 2 extreme situations I discussed. In one case I have only ordering cost, no holding cost.

And, in other case I have very low ordering cost almost negligible, and my holding cost is very high. So, I want to have a value between these 2 types of cost. So, that is what we do in our inventory management systems. And, this very beatifically we have already learn in our operation management class using the EOQ formulas. Economic Order Quantity formulas we have already learned.

So, now apply the same knowledge in this particular case. Now, as I was mentioning about the holding cost. Holding cost normally we represent with H. So, whatever we are doing for installation 1, we will use subscript one for that purpose. And, whatever we will do for installation2. We will use subscript 2 for that purpose. So, we have the holding cost at installation 1 as h1, and holding cost at installation 2 as h2.

These are the 2 holding cost we are already incurring. Now, because as we are coming from left to right, as I said we are adding more value to our products. So, product is more valuable from 1 to 2. And, since holding cost is paid on the material value of the product. So, always and always you can understand that h2 h2 because, it is on the right side of installation 1. So h2 will always be greater than 1.

You can understand why h2 will always be greater than h1. Because, h2 you have added more value by the time product reaches this stage 2. Installatiion2. You have added more value to that product, and therefore h2 will be more than h1. Then another important thing is we have also discussed there will be the order cost. So, order cost let us represent as K. So, there are ordering cost at installation 1 as K1 and order cost at installation 2 as K2.

These are our ordering cost. Now to further understand that how EOQ model will operate, because now we are going to the stage of making the model for these 2 stage inventory management. And, for that purpose in our last class, we discussed this particular graph where we had the system of inventory management like this.

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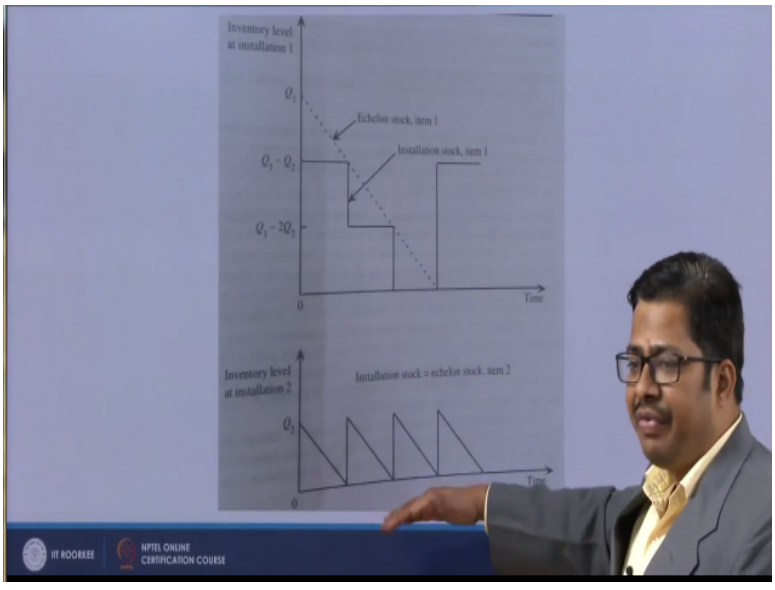

You are procuring or at a time you are giving order of Q1 items at stage 1, and Q2 items at stage 2. Now, Q2 item you have received here, we discussed you received Q2 here, and the installation

2 let us say is retailer. So, the rate of consumption of these Q2 item is being represented by this slanted line. This slope line represents the rate of consumption of these Q2 items. Then sometimes this Q2 item will finish.

And you will have 0 inventory level. So, this is the point where we achieve the 0 inventory level, but because of our modelling, because we know many things we have already ordered in advance that by the time you go to this 0 level. You get a fresh stock of Q2 items. And all of a sudden as soon as you are touching this 0 level your new stock comes and your inventory level again reaches to the original Q2 level. So, this vertical line represents the replenishment of the stock. So, if I say in this particular graph if you see in this particular graph we have these types of curves.

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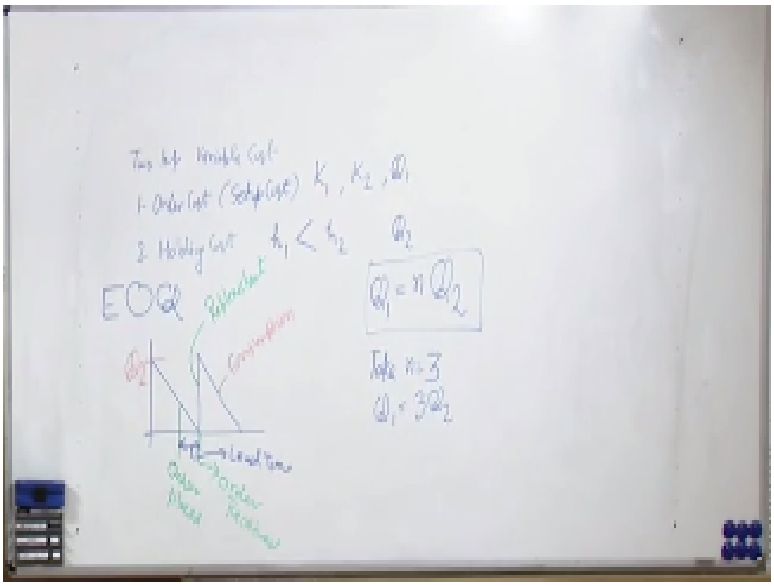

So, these lines which are straight lines, these are the replenishment lines. And, the slanted lines, these lines are the consumption line these lines represents the rate of consumption of your Q2 stocks. This is the Q2 level, and these slope lines are the consumption line. So, we have planned in such a manner. That if I am going to have my 0 inventory on let us say 30th of January.

So, immediately on the same date I will receive the fresh supply of Q2 items. So, that my replenishment line shows that instantaneously my stock will again go to the original Q2 level. So, that time, and for that purpose if this is the time I am going to receive fresh the suppl. So, I

somehow order at this point. Here I have ordered this is time order placed. And, this is the time order received.

The difference between these 2 times, when I am placing the order and when I am receiving the order, this difference is known as lead time. The time between placing an order and receiving the supply, so I already about my suppliers, that what is the lead time. My supplier, my predecessor can supply me in 2 days, 3 days, 5 days, 7 days, 15 days I know the capability of my supplier.

And accordingly I decide the lead time if my supplier can supply in 5 days. So, I will know that after 5 days my stock is going to be 0. So, I will give my order 5 days before. If my supplier need 7 days, so I know that after 7 days my stocks will go to 0 level. So, I need to order 7 days before. So, as per the capability of your supplier, as per the lead time they take to supply the product I decide the date of placing the order.

Nowadays because of influence of Japanese manufacturing systems in various domain of and so on in operations management, and so on in case of supply chain management also. More and more companies, more and more supply chains are looking to reduce this lead time. And there is a concept coming and many of you may be aware also, that we want to have 0 lead time. We want to achieve the 0 lead time also in our supply chains.

And, if we achieve that 0 lead time, that today I order, and immediately I got the supply, that is just in time. As soon as I require the product I immediately get it. So, we are continuously looking to shorten the lead times and, for that purpose it is very much important to develop the capabilities of my supply chain partners. In such a way that they can supplying with minimum possible lead time. Because, of so much volatility, because of so much uncertainty, because of so much complexity, ambiguity.

Because, of all these reasons I do not want to keep long lead times. Things may change all of a sudden, and if I have already place some order, and today I do not want, because the things have changed. So my supplier will force me to honour the orders. But, if lead time is small, I can give

order only when it is required. So, it is the capability of the entire supply chain. That we need to develop for reducing this lead time.

So, these system is there, and this system which is being represented here also is known as saw teeth pattern of inventory management. Shows, saw teeth type of arrangement between the replenishment lines and the consumption lines. So this is the Saw teeth type of pattern and whenever you this Saw teeth pattern.

At that time you can apply EOQ model of inventory management, or you can say also that Saw teeth pattern enables you to apply EOQ model of inventory management. So, now at installation 2, it is very clearly visible that I can apply the EOQ model. But, now let us come to installation 1. At, installation 1, because installation 1 is responsible for supplying products to installation 2.

All the supplies to installation 2, that come from installation 1. Now, therefore for better inventory management what we have done that whatever supplies we are getting at installation 1. Or whatever we are producing at installation 1. From that whenever we receive a new supply, a part of that goes to installation 2. And, we are left with some less amount of inventory.

And, that is what we have exactly made on this graph. Here what we have taken that this at installation 1, the items which we are procuring these are Q1, and installation 1. Items which we are procuring these are Q1. Just for the sake of understanding, we normally need to have and you will soon understand, that the item which we are procuring at installation 1. I am telling you a very simple relation between what we are procuring at installation 1. And, what we are procuring and installation number 2.

There is a simple relationship between the quantities which we want to procure at installation 1 and installation 2. Now installation 2 we are procuring Q2 items and it is very simply now clear to us that you can apply the EOQ model to determine the values of Q2. Now what to do with Q1 and what is this N here. For this purpose just for the understanding purpose we have taken, and equals to take 3, and equals to 3, and therefore Q1 becomes 3Q2.

We are procuring 3 times of Q2 at installation 1. So this is the Q1 we procure whenever we order this size of Q1 and out of that whenever I receive a supply of Q1 immediately Q2 supplies go to the installation 2. So I am left with Q1-Q2, and I will continue with Q1-Q2 for some period. Then in a mean time at a installation 2these Q2 items are finished. So I am left with Q1-Q2 here, so I will supply again Q2 items from this Q1-Q2 to installation 2.

So, I am left with Q1-2Q2 this and then after sometime these Q2 items at installation 2 are also finished. So, I am left with then I will supply remaining Q2 also and I am left with zero inventory. I have no inventory at installation 1, so this is the zero level from this period to this period there is no inventory at installation 1. Then again after sometime installation 2 requires Q2 items, so what I have done.

I have adjusted my procurement cycle at installation 1, in such a manner that whenever there is a fresh requirement of Q2 items at installation 1 only then I will procure Q1 items at installation 1. And, like this in this particular case when these Q2 items are required here. So I am procuring again Q1 items here, So you see where my finger is. The tip of my finger represents the Q1 a stock and the out of an Q1 stock again I have supplied Q2 stocks to installation 2.

And I am left with this much that is Q1-Q2 and again the same process will be repeated this step process is repeated. Now, it is simple to see that at installation 2. You have the saw teeth pattern at installation 1, you have this type of a step pattern of inventory management. So, at installation 1 we do not have the system of EOQ, because of saw teeth pattern is not available there. But then there comes a new concept that is the concept of Echelon stocks.

So, for we discussed only about installation stocks, that, whatever inventory is available at this particular installation, installation 1, installation 2. So, whatever inventory is available at installation 2, I am discussing about that only. So, these thick lines are these thick lines are representing that installation a stock. But, now we are going to introduce the new concept that is Echelon stock.

Now, Echelon stock is that when I am in the supply chain environment, so whatever inventories are available at this stage, and all downward stages all right stages in my supply chain, put together at a particular time that is known as Echelon stock. So, in these particular cases only two stocks are there. So whatever inventory is available at installation 2 that installation stock as well as Echelon stock is same. Because, there is no right side entity in this particular case.

In case of 1 since right side is 2, so the Echelon stock will be whatever, is available at 1+ whatever is available at 2 at a particular time. So by this new definition we have a very interesting thing that if you see on a particular time of starting time of a new cycle that day of a starting time of a new cycle. Let us on this very first day So, you have the physical stock and installation 1that is Q1-Q2.

And, physical stock at the next stage at installation 2 is Q2. So, total a stock on the day 1 becomes Q1-Q2+Q2 that is Q1 this point the top point of this curve. Then, we are continuously consuming these items and at this particular time or at this particular time you see your total stock is Q1-2Q2. And, what is there 0, so you have this much inventory available in your total stock. Here installation 1 + installation 2.

At this particular point you have 0 inventories here, as well as 0 here also. 0 here and 0 here so 0 + 0 becomes 0 here. So, in a 3 cycles of installaton2, first cycle, second cycle, and three cycle, so in these 3 cycles the inventory at installation 1, has moved Echelon inventory at installation 1 has move from Q1 to 0. And, similarly if you see other cycles also, the same pattern will be repeated, and when I join this Q1 point which is physically not there.

But, now since we have the concept of Echelon stock. So, this Q1 can be become conceptualized. And, this dotted line which is joining Q1 to 0. And you can see this dotted line will pass from these corner points of the steps, and this dotted will be followed in subsequent replenishment cycles also. And, then you can see that these dotted lines are also making a saw teeth pattern at installation 1.

And therefore we can apply EOQ model at installation 1 also. So, we stop here, in this session here, and in next class we will see that how this EOQ model will be applied at stage 1, and stage 2 of the inventory management. Thank you very much.