Supply Chain Analytics
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Lecture-31
Optimal Level of Product Availability In Supply Chain

Welcome friends, we are discussing about various types of decisions in the supply chain and in last few sessions we discussed about inventory management in the supply chain, along with inventory management there is one more issue which we will like to discuss in today's session that is about the level of product availability in a supply chain and it is very crucial to discuss about the level of product availability.

Because this on one side can take your supply chain to the responsive supply chain, on the other side it can take you to the efficient supply chain.

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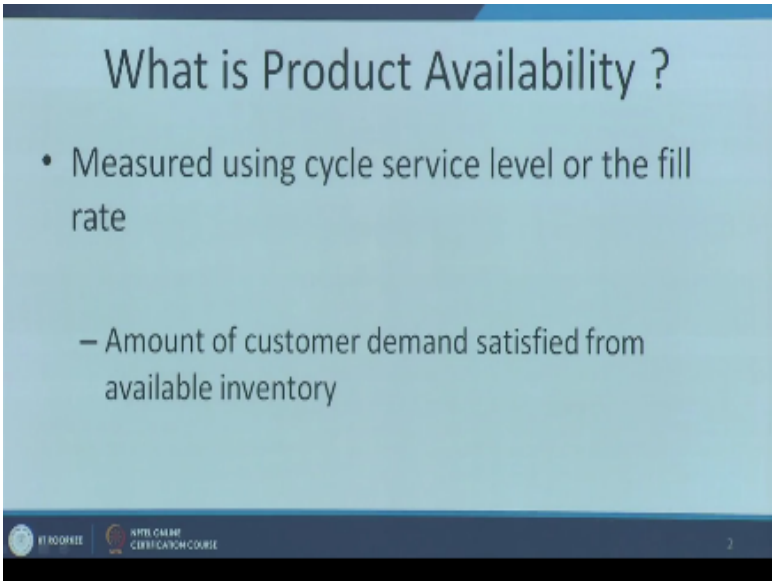

Now let us first understand what is the meaning of product availability?. The meaning of product availability is that customer is going to a supply chain or customer is going to a retailer and how many times the customer demand is satisfied from the available inventory and a customer I am going to a shop let say in a week 100 times, so out of 100 times my demand is fulfilled from the available inventory in the shop let us say 90 times.

Ten times I am not able to get the product which I am deciding, so I will sell the product availability is 90%, sometime in literature we also called as service level all the filtrate, these

are other terminologies which we used to define the product availability. Service level is a very common term which we used to define the product availability. Now it is very easy to understand that customer satisfaction is directly related with the product availability.

If we want higher level of customer satisfaction we need to increase the product availability. Now increasing product availability is directly related with the stock keeping unit, you should keep your number of units in your stock, so that you can offer higher product availability. So when you are offering her availability it means your supply chain is more responsive whenever customer comes you are able to fulfill the requirement of the customer of the shelf.

So that is a responsive supply chain, without any time delay you are fulfilling the customer requirements. On the other hand if a customer is coming and you are not providing product immediately and you ask customer to wait and you are looking for a pull type of supply chain where you will ask your next number in the supply chain, next stage in the supplied to supply the product as per the customer requirement.

So obviously because time delay is there the satisfaction level of customer maybe slightly less, so if you go for very high product availability, you go for a very high service level, you incur more inventory cost, and if you go for very efficient supply chain where you see that I should not stock and inventory and I should only ask for inventory whenever demand is there. So in that case customer satisfaction level is low.

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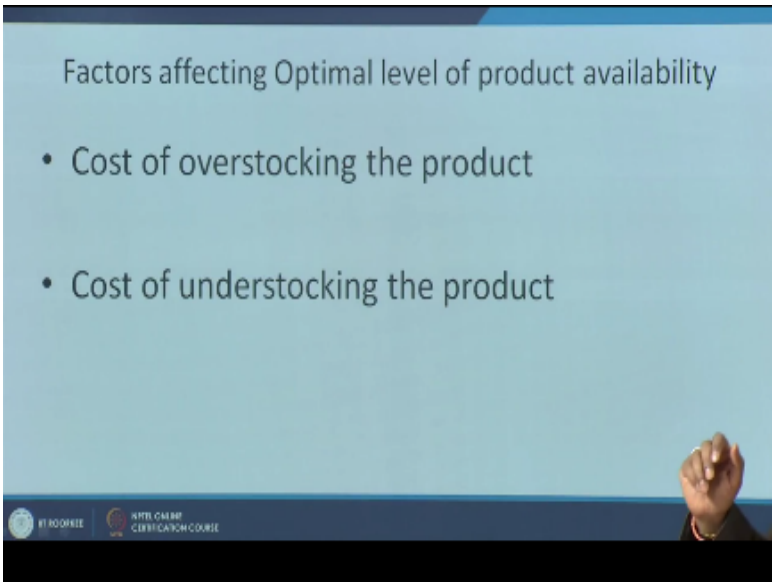

So we need to see the optimal product availability, that what should be the optimal product availability, so that we can maintain a balance between these two things, a balance between the customer satisfaction and the cost of keeping the product in the stock, so that is the optimum level of product availability we are talking in the session. Now the product availability, the optimum level of product availability depends on these two important facts. The first is cost of overstocking the product and the second is cost of under stocking the product.

Now what is the cost of overstocking and what is the cost of understocking, to explain these things considered a very simple situation that I am stocking let us say I am at the top of the some picnic spot and where tourists are coming and I am keeping some rain coats with macro environment, at that point I am keeping some rain coats with me because it is very likely that at any point rain may occur there.

Now when I am keeping rain coats with me and these are I am paying some price for that, cost price and let us say today I stalked 20 raincoats and only 10 customers came to my shop because there was little rain, so I have stocked 10 additional raincoats which were not sold today and because of very poor quality of rain coats the rain coats which I am keeping today at the end of the day are not able to sell tomorrow.

These are use and throw type of rain coats. So these cost which I have incurred for those 10 additional raincoats which I could not sale today that cost will go for the cost of overstocking, because the demand was of 10 raincoat today only and I stocked 20 raincoats, 10 additional raincoats, so that will go for the cost of overstocking. Cost of understocking again I stocked considering the yesterday's experience I stocked 10 raincoats today, but today because of cloudy weather because of rainy weather around 25 customers came to my shop.

But I stocked only 10 rain coats, so I could sell only 10 records and for remaining 15 customers I could not give the required products. So now the profit which I could have earned from selling those additional 15 raincoats I was deprived of that profit and this likelihood of the profit which I could have earned and I could not earn because I did not stock enough number of rain coats this is going to be the cost of understocking.

So I want to have a balance between these two things, cost of overstocking when I am stocking simply now we put in a generic form the cost of overstocking is cost when I am stalking more than the demand, the additional cost which is there because of stalking more number of units than the demand. Cost of understocking I am slightly pessimistic and because of my pessimism I stocked less number of units and demand was more.

So I was deprived of that additional profit, so that is cost of understocking. So we need to see that a balance has to be created between these two types of cost and for that purpose we will see with the help of a numerical example that how do we model such a situation where we need to decide about the optimum level of product availability.

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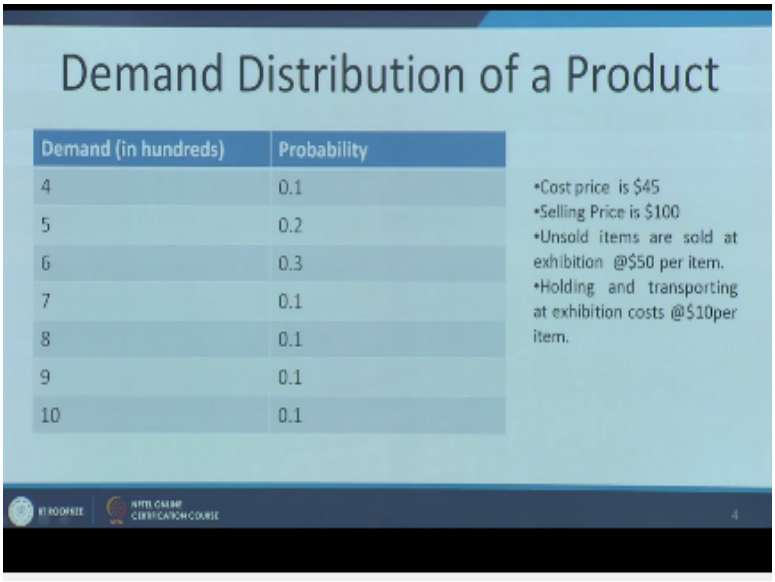

For that purpose we have this type of demand data available with us where the demand of the product in hundreds of the units are like 400, 500, 600, 700, 800, 900 and 1000 and on the basis of our past experience we have given these levels of probability of these levels of demand. Then the probability of demand is 400 units is 10%, probability of demand being 500 is 20% and so on that demand is 1000 the probability is 10%. Now I need to calculate out of this demand table that what should be the optimum product label I should keep in my stock.

And some of the additional data available to me that is the cost price is for this item for which we are discussing is 45 dollars per unit. I am selling this product at the rate of 100 dollars, the unsold items if there are certain unsold item because of overstocking the unsold items I am

able to sell at some exhibition at the rate of 50 per item, but in exhibition the cost of holding the inventory and transportation to the exhibition side is 10 dollars per item.

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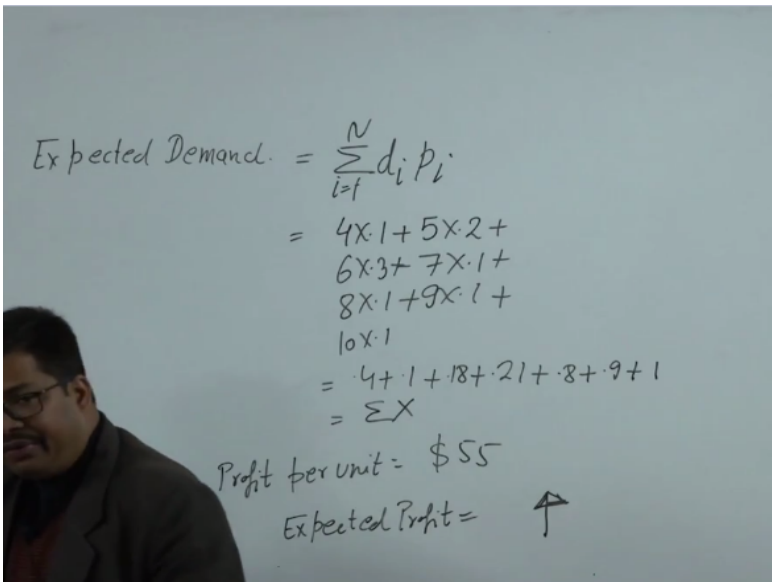

Now there are different things which we will like to calculate. The first thing which we will like to calculate that is the expected demand with the help of this data first thing is to determine the expected decor the different levels of demand and their respective probabilities are given to us. But the expected demand considering this whole situation is sigma of demand at a particular time and probability for that level.

So I = 1 to n, so your expected demand becomes 4 x 0.1 + 5 x 0.2 + 6 x 0.3 + 7 x 0.1 + 8 x 0.1 + 9 x 0.1 and + 10 x 0.1, that is why expected demand. Now I will like to stock any number of units as long as why is stocking that additional unit, my expected profit increases if I my expected profit does not increase I will not like to stock additional unit.

So the underlying condition because this is my expected demand, so this expected demand becomes 0.4 + 0.1 + 0.18 + 0.21 + 0.8 + 0.9 + 1. So this is my expected demand. Now cost price is 45 dollar, the selling price is 100 dollar, so profit per unit is from the given data 55 dollar per unit. Now I will multiply this expected demand with this profit per unit this will give me my expected profit that with this type of data this is my expected profit that 0.5 and you can do the sigma here and this sigma which is like the sigma x, sigma x multiplied by 55. This is my expected profit.

Now the meaning of expect optimum level of the product availability is that I want to increase this expected profit, as long as by stocking additional units my expected profit is increasing, then certainly I will like to stock additional units, but if expected profit is not increasing I will not like to stock additional units. We can show the meaning of that what is the meaning of that additional unit with the help of another way of doing this calculation of expected profit and probably then this calculation will be more clear to us.

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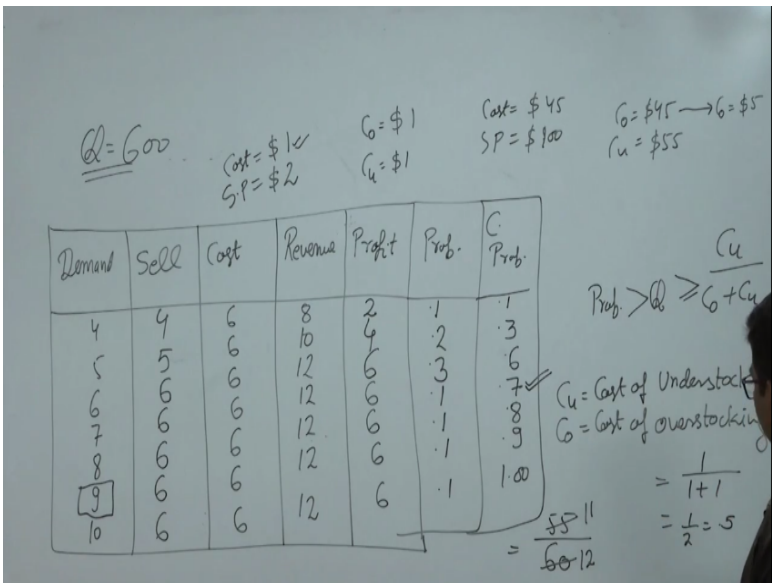

Now in this table if we see the data the maximum probability is associated with the demand level of 600 units, that is the 0.3, so just by seeing this data it looks that I should stock 600 units because that is the maximum probability. So I also take this as an initially that I should stock 600 units because this is going to maximize my profit, because this is I feel just by seeing this data that maximum probability is associated with 0.3.

So obviously I should stock 600 units, now when I am stocking 600 units, so let us say what will be the calculation of my this is the demand that is 4, 5, 6, 7, 8, 9 and 10. Now this is the sell when I am stalking 6, so I will be able to sell all 4 units which are the demand, when 5 is the demand I will be able to sell 5 units, when 6 is the demand I will be able to sell 6, but when demand is 7, 8, 9 or 10 because I have stocked only 6 units.

So I cannot sale 7, 8, 9, 10 out of 6, so my sell will be 6, 6 ,6, 6 in all these cases weather demand is more but since I have stock the less I will not be able to sell more number of untis, so these are the cells data. Now the cost data, cost price is 45 dollars, let us likely simple cost

price, cost prices is in this case is 1 dollar and selling price is 2 dollar, so it will make our calculation likely simpler.

So since cost price is 1 dollar and I have purchased 6 number of products, so my cost is 6, 6, 6, 6, 6, for all these levels my cost is 6. Now comes to my revenue I sold 4 newspapers, my selling price is 2, so 4 x 2 revenue is 8, 5 x2 revenue is 10, 6 x 2 revenue is 12 and then for all other periods I am selling only 6 newspapers, so it is 12, 12, 12 and 12 and therefore I calculate my profit which is revenue – cost, profit is revenue – cost, 8 – 6 profit is 2 10 – 6, profit is 4, 12 - 6 profit is 6 and then subsequently for rest of the rows profit is 6 rupees or 6 dollars or 6 minutes whatever you say.

Now please see the probabilities these are probabilities 0.1, 0.2, 0.3 and then for remaining four levels it is 0.1, 0.1, 0.1. So now just to summarise the expected profit is the multiplication of 2 x 0.1 the probability of happening of profit of 2 dollar is 10%, probability of happening the profit of 4 rupees 4 dollar is 20% and so on these are the probabilities of different levels of profit, so my total expected profit is sigma of all these products that is 2 x 0.1 + 4 x 0.2 + 6 x 0.3 + 6 x 0.1 + 6 x 0.1 + 6 x 0.1 + 6 x 0.1.

So these are the 1, 2, 3, 4, 5, 6 ,7 so this is my total expected profit where I am stocking 600 number of products. Now somebody will argue that I should stock 7 number of units or 8 number of units, so I will take this decision whether two stock 7 or 8 or 9 only when I do this whole calculation again by considering the seven or considering the 8 and calculate this total expected profit.

If this total expected profit is higher by is talking more number of units I will like to go with that decision but because of cost of overstocking it is quite possible that my stocking more number of units I do are negative direction, my total expected profit may decrease, so that is the meaning of optimum level of product availability, that which level of queue I should keep, so that my total expected profit is highest, is maximum.

So for that purpose we have already discussed about the cost of understocking and cost of overstocking. This cost of overstocking and understocking help us in developing a model for which we can use that optimum quantity which we should stock and for that purpose let me take you to one more step in this table.

In the table we will add one more column and that column is of cumulative probability, and that cumulative probability will be 0.1, 0.3, 0.6, 0.7, 0.8, 0.9 1. This is cumulative probability column. Now what is the meaning of disability probability that let us say I take this data **0.7** 0.7 or 70%, now this data. 0.7 says that 70% X 70% of the time demand is less than 7, 70% of the time demand is less than 7, now if you see the earlier quantity q=6.

For that the cumulative probability is coming 0.6, now the meaning of this 0.6 is that 60% of the time demand is less than 6, but 40% of the time demand can be more than 6 also, so whenever demand is more than 6 I will not be able to fulfill that demand so that will go for my cost of understocking but 60% of the time is less than 6 or up to 6 the quantity ordered equal to 6 will help me to achieve my service level.

But now as we all know that 60% service level is a very low service level and in most of the products which are becoming commodity this service level is absolutely very low, so we need to see that how to increase that service level and for that purpose this concept of cumulative probability is going to help us. Now in this case we now calculate a probability that demand is more than q, probability that demand is more than this q should be more than or equal to one relationship which is this.

Cu upon Cu + cu where Cu stands for cost of under stocking and Co stand for cost of overstocking, so now taking this data which is available to us let us take this date first of which is a simple data, here cost price is 1 rupee and selling price is 2 rupee. Now if I have some unsold items**,** so on each unsold item I will incur a loss of cost price, so much cost of overstocking in this case becomes 1 dollar per unit.

If demand is more than what I am stocking and in that case I will not be able to incur the profit which I can get, so in that case the loss is 2 – 1, the profit which I could have earned but I was deprived of that profit, because I stocked less, so that is cost of understocking, so that is selling price - cost price, so this is again one**,** so now you will like to use this data of Cu and Co in this case so it becomes Cu 1 and as a matter of fact Co is also one, so one upon 1 +1.

That is 1/2 = 0.5, now this calculation of 0.5 tells us that we will take a level of cumulative probability which is just higher than 0.5 and I am coming from the top 0.1, 0.3 and immediately higher than 0.5 is 0.6 and corresponding to 0.6 the demand is 6, so this is my optimal level of product availability. I should maintain this level of product availability 6 in my organisation.

If I increase the product availability beyond this point, so my expected profit may decrease. This is the point where my expected profit and loss or imbalance, so this is the meaning of this calculation. Now take this data which is there in this slide, in this data the cost price is 45, the selling price is 100, so now if cost price is 45, selling price is 100.

So my cost of overstocking is simply 45 and cost of understocking the profit which I am not able to get that is 100 – 45, 55 dollars, but there is some other information also. That information says that unsold items, those items which I am not able to sell can be sold in exhibition at the rate of 50 per item 50 dollars, but in the case of going to exhibition, so the holding and transporting cost is 10 dollar per item.

So cost price is already 45 and in that cost price of 45 you add this cost of 10 dollars per item. So now if you are selling some item in the exhibition the cost of that item becomes 55 dollars, cost of that item becomes 55 dollar and you are selling that item at the rate of 50, you are selling at the rate of 50, so the only lost the cost of overstocking is actually the Lost because of additional stocking, so the cost of overstocking in that case because you have some opportunity to dispense of your unsold items.

So your cost of overstocking reduces to just 5 dollar per unit because you are taking a margin of 50 dollar, you are taking a revenue of 50 dollar and unsold items but 10 dollars is additional because of transportation and inventory at the exhibition, so your loss is just 5 dollar and cost of under stocking is 55, so if I go with this data so your new calculation will be cost of under stocking is 55 and cost of overstocking is 5 and under stocking is 55, so 55 + 5 that become 60 and if I do this calculation so it is 11 upon 12.

And this is very close to around 0.9 and with this data now I will like to is stock 9 units, so now the point which you can understand after this calculation and with the data, now in the

first case when we took this data here our cost of overstocking is actually very high, cost of overstocking is almost equal to cost of understocking, so therefore we become conservative.

Conservative means we will like to stock less because otherwise our losses will be very high, in the second case when we use this data here the cost of overstocking is less as compared to cost of understocking it is much less actually today, so when cost of understocking is much less like this so we can take some chances and when we can take some chances the meaning is that we can think of stalking higher quantities.

Because with higher quantities the loss is not much even if I go with this 10 number of items 10 units, so loss is 5 units per dollar per item and therefore I can take this type of risk in my decision making, so the relative proportion of cost of over is talking and cost of understocking will decide my actual decision that what should be the optimal level, but this formula will help me this I request that you should remember that formula that cost of understocking upon cost of overstocking + cost of understocking.

This formula will help us to actually model the situations that what is the optimal level of inventory we should maintain or what should be the optimal level of product availability we should maintain in the supply chain at different stages so that we can have the maximum expected profit. So I hope we all can use at different stages in the supply chain this decision making pattern, so that we can give a decent level of customer service level and at the same time we do not incur excessive cost of offering that service level. Thank you very much.