Working Capital Management
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Lecture - 21
EOQ Technique of Inventory Management

Welcome students. So we are in the process of discussing the management of inventory, the first current asset and so far we discussed the importance of inventory and how important it is for the say financial managers as well as the production managers to manage the inventory in a efficient manner so that cost of managing inventory investment made in the inventory remains under control.

We maintain the optimum level of inventory and say finally we recover the investment made in the inventory well within the time so that the operating cycle remains optimum. Now taking the process further we will be learning more about the inventory managements so that the investment made in the inventory in the first current asset most illiquid current asset becomes possible to be managed very efficiently and whatever the investment firms makes that can be recovered at the faster pace.

Now we talk about the say management of inventory, the first current asset requires that it should have optimum investment or the firms should make optimum investment in inventory while building up this current asset as without inventory the show cannot be run, the firms cannot perform. So we have to build up the inventory level at all the levels that is of raw material, WIP, and the finished goods right. Now in this case, how to find out that optimum level?

You must have read sometime in the past about the techniques of inventory management or material management and most popular technique is the EOQ technique or Economic Order Quantity Technique. To find out the optimum investment in the inventory we take the help of the EOQ technique and that technique helps us to find out that amount or that quantity of the raw material to be purchased which is most economical for us right?

So we have to make use of that technique. There are number of techniques like JIT is another, ABC is another; different techniques of inventory management. So we some people, some experts in inventory management have started saying that EOQ has become say you can call it as not of much use now. It has become useless technique as it is not able to give us the appropriate quantity that should be procured, that should be purchased and that should be stored.

So we should resort to the other techniques or new techniques like JIT or the other techniques. But I would like to emphasize hereupon that even today also EOQ is that much important as it was in the past. Maybe it is not that important in the countries like Japan, US but the supply chain arrangements are very efficient where even by maintaining the lowest level of inventory by following JIT and other techniques of material management or inventory management.

They are able to run the production process efficiently but in a country like India we cannot think of abandoning the EOQ technique and since JIT is not possible to be implemented in all the industries in all the firms in the country or in a country like India so we have to still depend upon the EOQ.

And we will prove it empirically or by say certain models that whatever the limitations you say or we talk about the EOQ has become an old technique or is useless technique or is a obsolete technique but we can say prove it that EOQ is still useful for us in the companies working in India or for the companies working in India and we will have to depend heavily upon the EOQ technique.

So first before talking about the limitations and say how to take care of those limitations or how the limitations of EOQ affect the management of working capital or say finding out the investment to be made in the inventory from the financial perspective or the financial point of view, let's just recall quickly what the EOQ technique is. You must have read this technique somewhere else.

Also while sometime studying about the inventory management or sometime material management so it is a old technique, it is a very you can call it as old in the process but it is

better for us in the class to recall what this actually the technique is, what are the important components of this technique and then if there is any criticism of the technique in the modern world then how to take care of that and how to justify that this technique is still useful.

So I would say that to find the optimum investment in the inventory to be made in the Indian scenario or by any manufacturing concern in India, they should depend upon or they can easily depend upon the technique like EOQ and there is no need to think about that this technique has become say obsolete or is not worth using now because thinking of JIT and other kind of techniques is also not that much feasible for all the firms or the industries.

So let us recall what is JIT and how to say make use of this technique. So you see that what we try to find out under JIT sorry this EOQ, what we try to find out under the economic order quantity, we try to find out that quantity of material which is most you can call it as appropriate and the cost of acquiring that much of the quantity we call it as a economic order quantity that it is most economical to acquire that much quantity.

And once that quantity is exhausted, fully utilized in the manufacturing process then should we replace the say old material with the new material until unless that existing order has been exhausted we should not go for placing the new orders and we should not buy the new material. So how it behaves you must be able to recall that saw toothed picture, the saw toothed picture is something like this we will be going for this and we will try to learn that what is saw toothed picture. It is some structure like this.

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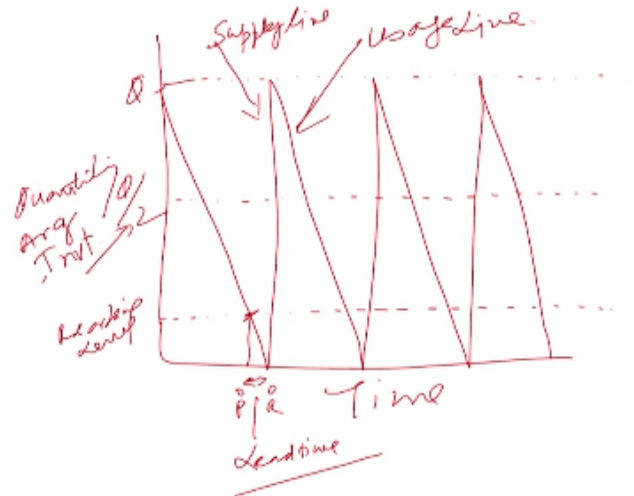
This is the structure of the inventory management and let us recall this structure. It is something like this. It moves from here. It goes like this. It goes like this. It goes like this. It goes like this and it goes like this. It comes down. It is called as a saw toothed picture and saw tooth diagram and in this diagram we can make out that this is the level of the material which is on this side we take the quantity or you call it as the Q.

This is the quantity of the material and here we take the time. So it means here we say that it is a Q level of the quantity of the material we are buying and we are here, when we have bought we have received the order of the material what we placed. We got the material and when we got the material, this is at this level and we start using it so it comes down to this level to the last level. When it comes down to this level then we again place a new order.

We replenish the material level to the beginning level and then we start using it comes down and this way this picture emerges like if you divide this here from here we call it as this is the average inventory level. This is called as average inventory level which you can say it is half of the Q level or it is Q/2. So it means we have this level of inventory, average level of inventory which we all the times maintain.

We say that normally this much of investment always remains so that is why it is called as the average investment to be made in the inventory and here when we talk about a third point, that

third point is somewhere here and that third point is called as reordering level. We call it as reordering level. As inventory reaches at this point we reorder it and if you draw a line here this to this, so between this area this is called as the say here we have placed the order, order placed and here it is the order received.

So we have received the order. So it means this is the time period you can call it as the cushion period. We have got the cushion period here from this place to this place because if you allow the inventory to come down to this level and if takes some time to receive the inventory so in that case it may affect the production process so what we do is we decide the reordering level that when it will reach at the lowest level or maybe the level where the placing the order is most optimum then we will be placing the order and we know that how much is the lead time required.

This time is called as the lead time to receive the inventory. The time taken to receive the inventory is called as the lead time. So that lead time we have to work out and accordingly we have to decide the reordering level and as per this reordering level we place the order, we receive the order. Again, when the inventory comes down to 0 then we replenish it with the same level that is the Q level of inventory.

So this process keeps on moving which we call it as the saw toothed picture and this is the way we can say that economic order quantity works. This is the average level. This is the average inventory at the Q/2 level. So average inventory means on an average this much of investment always remain remains in the inventory and we are not able to liquidate this investment or convert this investment into cash. So in this case what you see is we had lines here.

Say for example if you close this level, highest level is that is the Q. If you close this level you say this line is the you would say this line is the supply line. This line is called as supply line and this line is called as the usage line. So supply line takes the material back to the same level from where we have started that is to the Q level because it was 0 here. We placed the order when it was say something say above 0 we placed the order.

After finishing the lead time we came down to 0 level and immediately we received the order. So through supply line we again made it back to the Q level and then we started consuming it and when it will come down it will be reaching at the reordering level. We will place the order and this way the entire process works. So it is not a new thing. You must be knowing it. You must be remembering it what is this picture and how this picture will work or how this structure works and this is economic order quantity.

And when you say that how to work out the economic quantity, let us recall that also and you must be knowing it that we take into consideration 2 cause for deciding the economic order quantity level.

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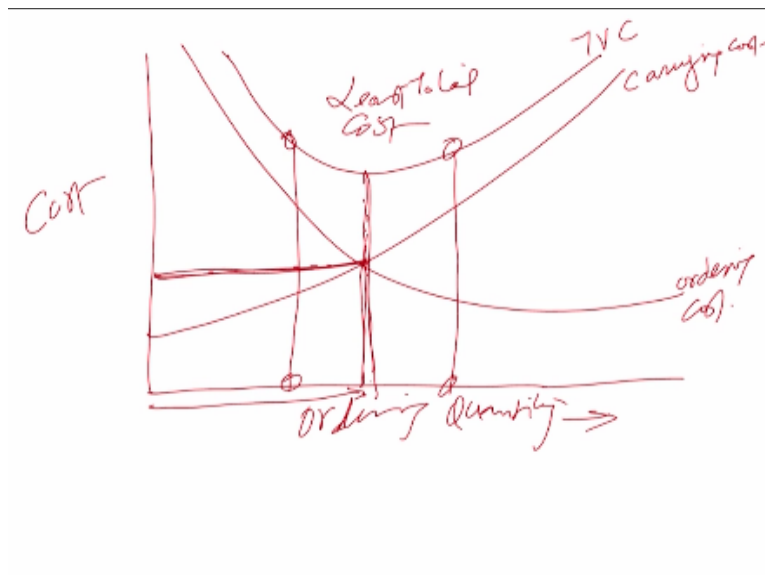
Why we call it as the economic order quantity? Because the cost of the material acquired at this level or by deciding this much of the quantity is available at the lowest possible cost and that is the total cost, lowest possible cost. You see that we have the 2 kind of the cost which are associated to the inventory. So first cost is the carrying cost, which is the purchase price plus transportation cost.

And other kind of the cost which we incur while we purchase the inventory and until unless we convert that inventory into finished product and finished product becomes sales and sales convert into cash that investment remains blocked. So that is called as a carrying cost. So one cost is the

carrying cost. The another is the ordering cost right setup cost or you call it as the ordering cost. So if you keep the inventory level high right. So what will happen?

Your carrying cost will increase because you are investing more funds in the inventory. Inventory is remaining as inventory for the longer duration and funds are blocked in the inventory for the longer duration so it means that what will happen, your carrying cost will increase. But if you lower down the inventory level, so what will happen? Time and again you have to place the orders and ordering cost itself is a high cost.

And when the ordering cost will increase so it means what is happening you are lowering down one cost. If you are lowering down the carrying cost, ordering cost is going up. When you are lowering down the ordering cost by not ordering it frequently, very frequently your carrying cost is going up. So it means ultimately that is not called as the economic order quantity. Economic order quantity is the one where the total cost of acquiring the inventory is the lowest.

That is the economic order quantity. I think you will be able to recall it. So let us see how we work that cost. Here we have the cost on the x axis and on the y axis we have the ordering quantity. This is called as ordering quantity. This is the quantity we are going to order or this is the quantity which is going to be there with us. So we have something like this. It moves like this. So in this case in the ordering quantity this cost behaves like this.

This is called as the carrying cost. And this cost is called as the ordering cost. So this cost is the carrying cost and this cost is called as the ordering cost. So what is happening? If you are reducing the level of orders, if you are coming from this side to this side what is happening? Your ordering cost is going up because you are keeping this much level of the inventory and again when it comes down to 0 or maybe to the lowest level, you have to again place the order.

So the ordering cost will go up. But if you go from this side to this side and you keep more stock of inventory with you in that case your carrying cost will increase right? So we will have to find out the quantity that will be called as a economic order quantity and that will be something like a point where both the cost are equal. So you say this is point where both the costs are equal. When

the carrying cost intersect with the ordering cost, that quantity will be called as the economic order quantity.

This quantity is called as a economic order quantity and here both the costs are equal, the ordering cost and the carrying cost are equal so this we say that this is the cost. If you draw a curve here you will find something this is the least total cost. This is the least total cost. Here also the cost is very high. Here also the cost is very high. So you would say at this level the least total cost this is the least total cost.

So here if you try to find out the cost here so this is the cost and in this case this is the least total cost and out of the total cost both the sides if you are going from this side to this side you are here at this level and from this level to this level the cost is very high. From this level to this level the cost is very high. At this level only the cost is lowest. So it means this will be called as the quantity which is called as the economic order quantity.

Where your total cost is the lowest and both the costs they are equal, carrying cost is equal to the ordering cost and vice versa so this quantity of the raw material which we are going to purchase from this to this is called as the economic order quantity right. So it means when you say that this curve is total variable cost right. This curve is the total variable cost so it means in this case this is at the lowest total cost at this level.

So it means we have to acquire this much of inventory and this inventory is called as the economic level of acquiring. We place the order and that order is keeping the cost at control at the lowest level. But here people say that this economic order quantity process has become obsolete and in today's competitive scenario we should move to the other techniques like JIT, ABC technique of material management or the other techniques of material management but that is not correct.

Even today, as I told you just in the beginning of the class that even today it is very useful to say use the economic order quantity process and there might be some problems. People say that to assess the ordering cost, there are say difficulties in assessing or finding out the exact ordering

cost. Carrying cost if you try to find out there are the difficulties in finding out the carrying cost and the total investment which we plan to make or we are going to make there is a problem to find out that total investment we are going to make.

So if we are not able to work out the cost, total investment we are going to make how can you think of working out the carrying cost. Agreed that it cannot be worked out with the total precision. There is a possibility that the carrying cost we are working out in the beginning and the carrying cost actually taking place that might be different. Similarly, if we talk about the ordering cost because ordering cost involves many things.

And the people, the human resources who are working and dealing with the ordering of the materials, they are not only doing this job. They are working for the other things also. So it means the salaries they are being paid, what part of their salary should be say apportioned and that should be attributed to this particular job, the ordering of the inventory job, that is again very difficult.

So yes, we agree that if it is a temporary workers and doing this kind of the ordering job only then it is fine it is easy to calculate the cost, ordering cost. But if some people who are working on the multiple things, finding out the ordering cost will be very difficult because out of the total their salaries cost, the salaries they are being paid, they are doing many things so how to find out the ordering cost. So there is a problem, agreed.

But still if somehow if you are able to find out the carrying cost and the ordering cost which is quite possible, which is quite easy, not every difficult and there can be differences also that what is the estimated cost and what is the actual cost, there can be differences. Despite that EOQ model or EOQ technique of inventory management is very useful even today or in the modern scenario especially in the countries like India or the developing countries.

Because this technique even today gives us the quantity of the raw material that can be purchased at the lowest possible cost and minimum investment of the short term funds can be made in the inventory. Now, we would see a situation that if there is a problem in assessing the cost it means

that will cause the error. If the assessed carrying cost or the estimated carrying cost and the estimated ordering cost are different and actual are different so there is a variance, there is a error in calculating the cost.

So how much that error is there. Whether that error is going to make a different or that error is not going to make a difference. Let us see about that, talk about that and try to understand that error. I will not I will take you to the say a model which is helping us to understand that what this technique is.

How it is possible to be say precise in calculating the cost and if there is an error in calculating these costs because of which because of these errors this technique is called as obsolete technique or need to be abandoned then let us see whether it is justified or not. So we can say that let us determine the error factor.

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We can now determine the error factors for different parameters as follows:

$$\text{Demands factor} = \frac{\text{Estimated demand}}{\text{Actual demand}} = m$$

$$\text{Ordering cost error factor} = \frac{\text{Estimated ordering cost}}{\text{Actual ordering cost}} = n$$

$$\text{Holding cost error factor} = \frac{\text{Estimated holding cost}}{\text{Actual holding cost}} = k$$

Denote $Q = EOQ$ and $Q^* =$ order quantity with estimation errors.
Hence, percentage variation in order quantity due to estimation error is given by:

$$\frac{Q^* - Q}{Q}$$

where

$$Q = \sqrt{\frac{2DC}{H}}$$

Incorporating the error factors in the model, Q^* becomes:

$$Q^* = \sqrt{\frac{2DCmn}{Hk}}$$

So how to what are the important components of the two costs, carrying cost and the ordering cost. Number one is the demand factor because how much material you will be ordering that will depend upon the demand and people say that there is a problem in estimating or forecasting the true demand or the actual demand for the product we are manufacturing or the different firms are manufacturing.

So let us see that let us work out the different errors and first is the demand factor. We have taken here estimated demand divided by actual demand and whatever the difference in the estimated demand and actual demand is there that is called as the demand factor and let us denote that factor with the M. This factor is denoted with the M. So this is one thing. Second thing is now the error factor for ordering cost.

We say that ordering cost is very difficult to find out the ordering cost as I just told you that the people who are working for ordering of the material they are not only doing this job in the firm they are doing many other jobs also and since they are permanent employees they are getting salaries so how to apportion attribute the part of their salaries towards this job towards this function so it is very difficult.

So there can be the error or there can be the possibility of the errors and say we have estimated that error also. We have tried to find out the ways and means to identify that error also to estimate that error also and in that case ordering cost error factor is estimated ordering cost divided by actual ordering cost. That is only going to happen, only 2 things; estimated ordering cost and the actual ordering cost nothing else.

It means if there is a difference let us denote this error by N. Third cost is the holding cost or the carrying cost, holding cost or the carrying cost. It is sometime difficult to identify the carrying cost or holding cost that how much investment is required to be made, how much funds are required to be invested in say a given amount of inventory and what will be the carrying cost or holding cost for that.

So in this case estimated holding cost we can take for calculating this error factor for working out this error factor or the error factor for the holding cost. Estimated holding cost divided by actual holding cost right and we also get this error factor worked out and let us denote it by K. So it means now we have got them order. Denote Q, Q means that is quantity that is saw tooth picture first level that we call it as the economic order quantity.

And Q star is the order quantity with estimated errors means we identify actual EOQ level should have been say 500 units of a given period of time or a lot of the 500 units but be estimated or as per our estimate the economic order quantity which came of was Q star with the estimated errors and that was say 600. It means finally if you use this model you would say that how much variation is there. Our objective is to find out the variation.

How much variation is there? If you see the variation here then Q*- Q means estimated say quantity minus the actual quantity means quantity which is say estimated with errors and actual quantity which was purchased and which was called as the real quantity that is EOQ divided by the Q and here if you look at the model which is the standard model of the Q, EOQ model that is 2DC/H.

2 multiplied by the demand annual demand multiplied by the carrying cost divided by the holding cost and the root of this. This is standard model. No need to explain this model and if you incorporate the errors in this, if you incorporate the errors in the demand as well as in the carrying cost. So we have already identified here the error factor and demand is M. The error factor in the ordering cost is N.

So if you multiply by the error factor here so Q star becomes means the economic order quantity which is affected by the error becomes under root of 2DCmn/Hk; Hk is the holding cost and that is also full of error. So it means one model is this model which is the original model and one model is the another model which is the another model.

So it means if you talk about this in that case you would say that this is the one thing and another thing is that if you want to talk about this is the another thing that Q is 2DC/H under root and Q star is 2DCmn under root Hk sorry divided by Hk under root. So if you see Q and Q star we have got 2 important things. One is correct and the another one is the incorrect or full of errors. Now, let us see what happens.

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Hence, impact of the estimation errors on the estimated Q can be calculated as:

$$\frac{Q^* - Q}{Q} = \frac{\sqrt{\dfrac{2DCmn}{Hk}} - \sqrt{\dfrac{2DC}{H}}}{\sqrt{\dfrac{2DC}{H}}}$$

$$= \frac{\sqrt{\dfrac{2DCmn}{Hk}}}{\sqrt{\dfrac{2DC}{H}}} - 1$$

$$\approx \sqrt{\frac{mn}{k}} - 1$$

Impact of the errors on the demand or on the estimated Q as we have calculated here or which can be calculated here say the final model will become like Q* - Q/Q and if you solve this model here finally we arrive at this particular thing which is the last thing. So if you see here this last thing is mn/k under root - 1.

This becomes the final model and if you use this model you will be able to find out the error factor, how much error is there in estimating the economic order quantity and that will help us to understand whether it is worthwhile to use EOQ model or it is not worthwhile to use it has become a model which is obsolete; we should abandon it.

So it means finally after adjusting for the error factor and differentiating between the actual economic order quantity or the actual based upon the actual demand, actual carrying cost, actual holding cost and estimated demand estimated carrying cost estimated holding cost, the difference between these 2, if the difference is very high then yes the technique is obsolete. But if the difference is too low then you can say that yes there can be some kind of errors, problems in estimation which can be easily taken off.

But if that error is minute then the technique is still useful but if the error is big then yes certainly we will have to look for the alternatives.

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Let us understand this by varying the parameters of our earlier example.

Parameters	Estimate at EOQ	Actual	Percentage change
Demand (D)	7200 units	10,000 units	+38.9%
Ordering cost (C)	Rs. 1200 per order	Rs. 1000 per order	−16.68%
Holding cost (H)	Rs. 3 per unit	Rs. 4 per unit	+33.33%

Hence

$$m = \frac{\text{Estimated demand}}{\text{Actual demand}} = \frac{7200}{10,000} = 0.72$$

$$n = \frac{\text{Estimated ordering cost}}{\text{Actual ordering cost}} = \frac{1200}{1000} = 1.20$$

$$k = \frac{\text{Estimated holding cost}}{\text{Actual holding cost}} = \frac{3}{4} = 0.75$$

Impact of all the above estimation errors on estimated Q is calculated as below:

$$\frac{Q^* - Q}{Q} = \sqrt{\frac{mn}{K}} - 1 = \sqrt{\frac{0.72 \times 1.20}{0.75}} - 1$$
$$= 1.07 - 1 = 0.07 \text{ or } 7\% \text{ approximately which is not very high.}$$

Now let us see we take a data and use this model which we will try to find out here that say whether the technique is still useful or not. For example we have taken the parameters demand D estimated at EOQ level is 7200 units, actual is 10,000 units means we could sell that much of the product in the market. What is the percentage change, what is the variation in the demand for the product in the market, 38.9% that is plus positive means we estimated the demand 7200 units.

Actual demand was 10,000 units. So here is the error in estimating the demand or forecasting the demand. Now look at the second component ordering cost. Ordering cost is 1200 per order that is C. Actual ordering cost was 1000. So it means again there is a error here and that is means the estimated was estimated ordering cost was high. Actual ordering cost was low and there is a negative variation by 16.68%. Now we talk about the holding cost.

Holding cost is also different here. Holding cost we estimated were or was Rs. 3 per unit and actually it worked out as Rs. 4 per unit. So again there is a variation of 33.33% here right. Now finally how the model will work. We have already estimated or known how to estimate these error factors. That is estimated demand, error between the estimated demand and actual demand that is m. Error between estimated ordering cost and actual ordering cost that is n.

Error between estimated holding cost and the actual holding cost k and here we have out of the given figures here we have worked it out that is 0.72, 1.20, 0.75 right. Put all these figure now in

this model. This model which we have worked out in the previous slide here that is under root mn/k - 1 if you use this model which will capture the error in the actual between the actual and the estimated.

So it means finally the model is Q* – Q/Q is under root mn/k - 1 and if you put the values the error factors we calculated here with regard to demand, with regard to the ordering cost, with regard to the holding cost if you see here you will find out that total calculations are here something like this that is 1.07. So - 1 means which is the difference part. The estimated part is 1.07 and the actual is 1.

So the difference between the estimated and the actual is 0.07 or finally you can say 7%. It means the difference in estimation of demand, difference in estimation of the carrying cost, difference in the estimation of the holding cost or if you do not want to call it as a difference you call it as error. Error in estimating the demand, error in estimating the carrying cost, error in estimating the holding cost; nutshell the total error or the magnitude of that error is just 7%.

It means 7% which is at the acceptable level. It is less than 10% and anywhere when we are going for the forecasting of any demand because at the level of estimation we are forecasting we are only estimating. So certainly there ought to be a difference between the estimated level and the actual level. But if that difference is very high then what will happen. The that the EOQ worked out, estimated EOQ and actual EOQ will be much different so what will happen?

If it is on the higher side, estimated economic order quantity is very high so what will happen? We will end up making more investment than the desired investment or required investment so wasteful investment of the funds will be made in the inventory and we will not be able to convert that inventory into cash as quickly as possible. Or it can be vice versa that we have estimated it wrongly so actual requirement of the inventory was high.

We estimated it lesser and we are not able to serve the market or we are facing the stock-out cost. Now in this kind of the situation if that is the case yes certainly we will be facing the music. But in this case there is no problem at all; 7% difference between the estimated and the actual figures

is not a big difference. So ultimately we can prove it or it has been proven say it has been proved in the literature that economic order quantity is still a useful technique.

And in case of the working capital management also, management of the short term funds also how to find out that magnitude or the level of the inventory, economic level of the inventory which can be decided that we call it as the optimum investment in the inventory or that quantity which is called as the optimum quantity of the inventory which can be acquired which can be used which can be converted into finished product and which can be say taken to the market.

So in a country like India in all the developing economies we cannot say that we can use JIT so we will have to depend upon the economic order quantity. So it means finding out the optimum level of investment in the inventory or building of the current assets in the form of the inventory we will have to depend upon the economic order quantity even today in the time to come and this is a very useful technique.

So this is something like that we were talking about while say started discussion on the management of inventory that we should make optimum investment in the inventory so a big question mark was how to find out that optimum investment in the inventory and here the way out is that with the help of EOQ we can find out that level of inventory which is optimum, which is most appropriate.

And if you build up that much level of inventory, cost of inventory will be at control. Total cost of inventory will also be controlled. Investment will also be under control and converting that into cash or into sales will also not be a problem and finally all the objectives of optimum level of maintaining inventory, optimum level of investment in inventory and optimum level of sales and avoiding all kind of excessive cost can be achieved. So this is for today.

We will stop here and we will carry forward the discussion of management of inventory and in the say in the classes to come also I will carry forward the discussion and we will discuss many other things with regard to this particular current asset we will learn more how to manage the first and the foremost current asset, most ill equal current asset called inventory so that

investment in the inventory can be kept under control and that can be converted into cash as quickly as possible. Thank you very much.