Introduction to System Dynamics Modeling
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Lecture – 20.3
Supply Chain Models - III

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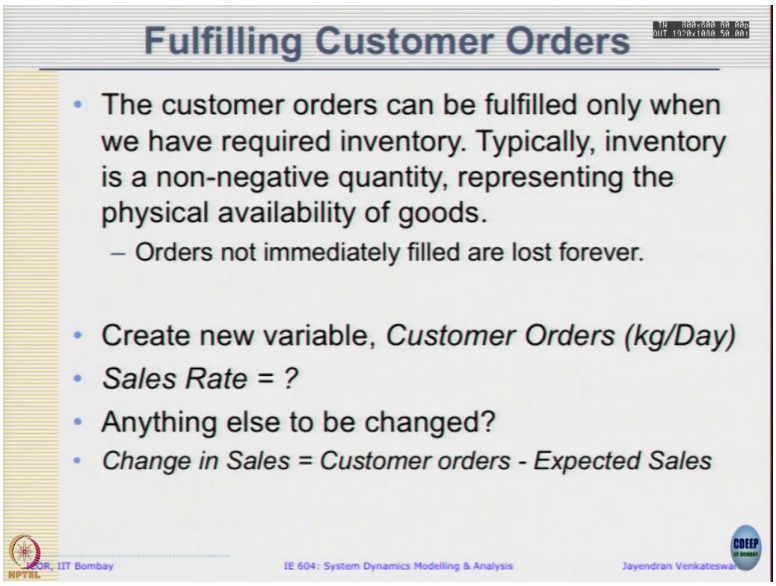

A fulfilling customer orders, ok. So, before that let me, yeah. Customers can fulfill only when we have required inventory. Typically, we want the inventory to be non-negative representing of physical availability of the goods, when that is orders not immediately fulfilled or lost forever.

Like, suppose you go to retail shop and you want to buy something, if it is not there, you go to next shop. It is very rarely you will say, I will come tomorrow and find out or we will wait for 2-3 days. As per it is a small retail shop settings or a time sense to item you do not need to

wait for it. You go, if not there that order is pretty much lost for the retailer, ok. So, we need to model this. Let us just take a look whether our inventory is actually going negative.

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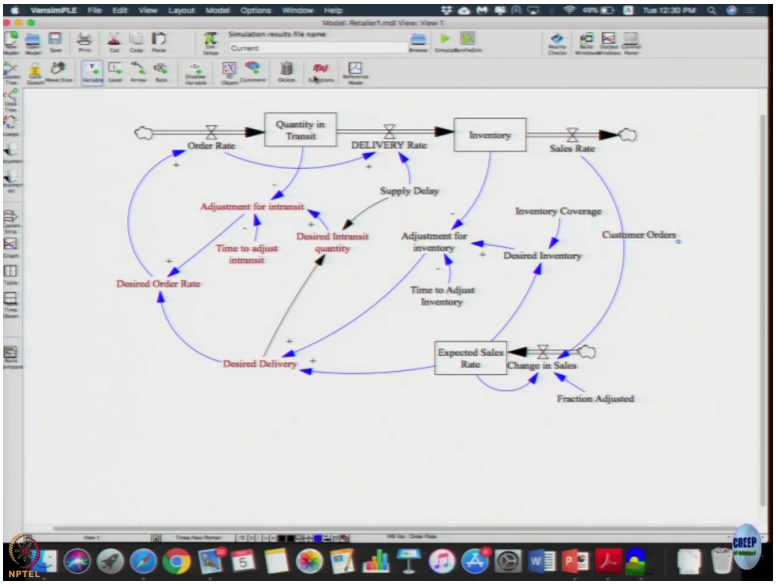

I am not sure it is going to happen, but let us see.

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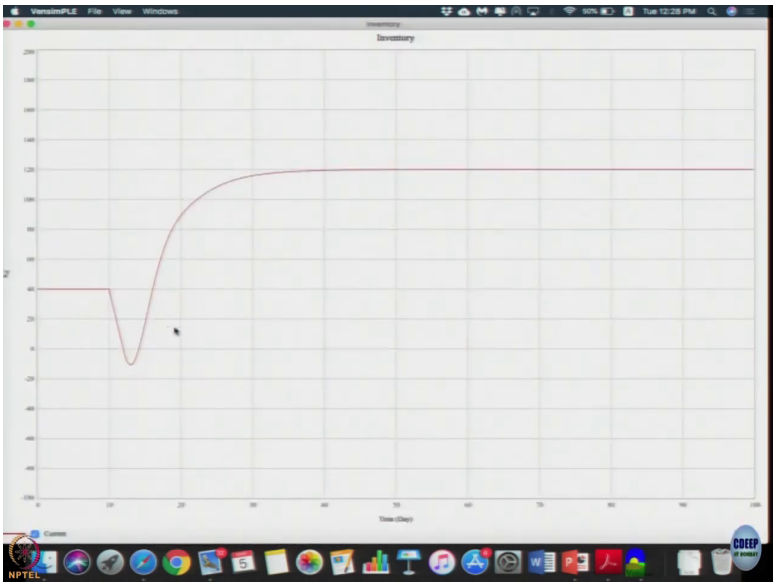

Inventory, yup is indeed. If you looked at the inventory graph in a previous setting, you can find the inventory was 40; then when demand increased even this simple setting it went below 0 from time period probably 12 to 15, it is negative inventory. So, this we do not want. We do not want the inventory to go negative. So, meaning if inventory is not there that demand is lost. So, ideally what we want is a straight line right here when demand is, when inventory is not there. So, what can we do? What can we do? We can, and create a new variable or customer orders, let us keep it separate. We will update the sales rate as per that and since we know the customer orders it directly change the sales, to change your expected sales rate based on the customer orders and the expected sales rather than the sales rate for now.

So, let us update this also in our model. Then how should the equation of sales rate be? What should be equation of sales rate? Go ahead. Let me do this, customer orders kg per day.

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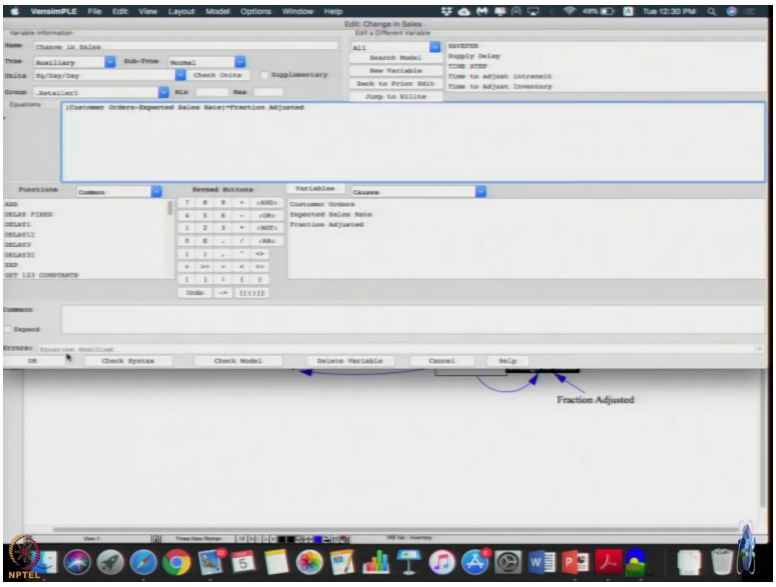

What are equations we had for sales rate we will just put it here, set of (Refer Time: 02:51) comma 10. Let me delete this.

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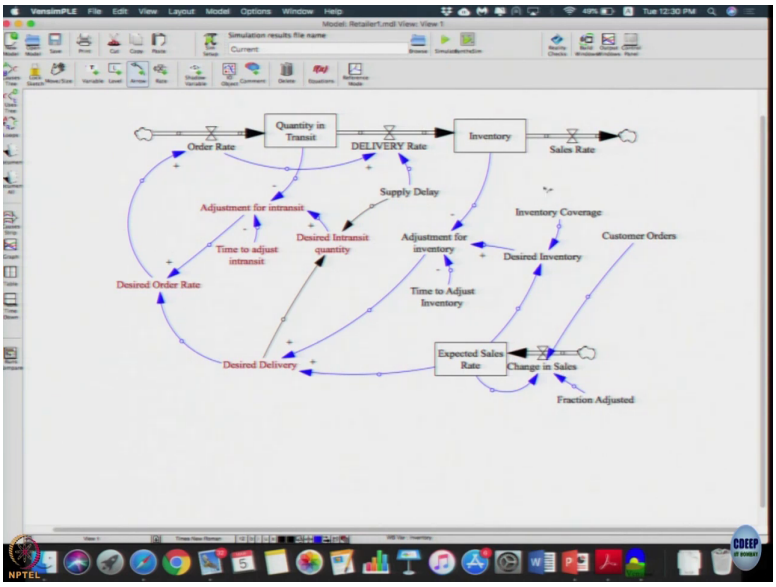

Customer orders. So, expected sales rate is now, changes based on customer orders. So, change in sales is.

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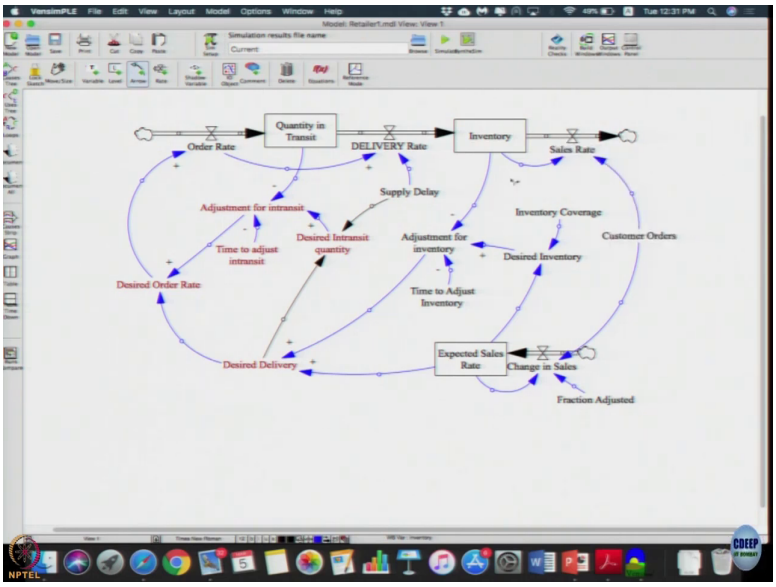

Basically, basically expected sales rate actually represent the expected or forecasted demand that is what it actually represents.

Now, how should the sales rate be, if I should not allow negative inventory? Let us do the simple one. Inventory, and customer orders, and sales rate in minimum of inventory and customer orders if that do a trick even its own match, one, first let me do both.

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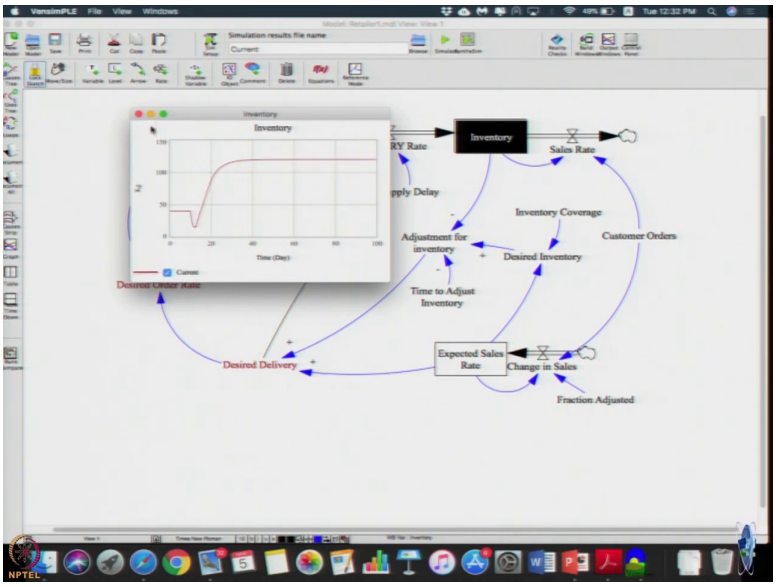

You simulate it, let us plot the inventory graph, does not hit 0, something is terminal truncated is right there. But if you do model units check so many units errors.

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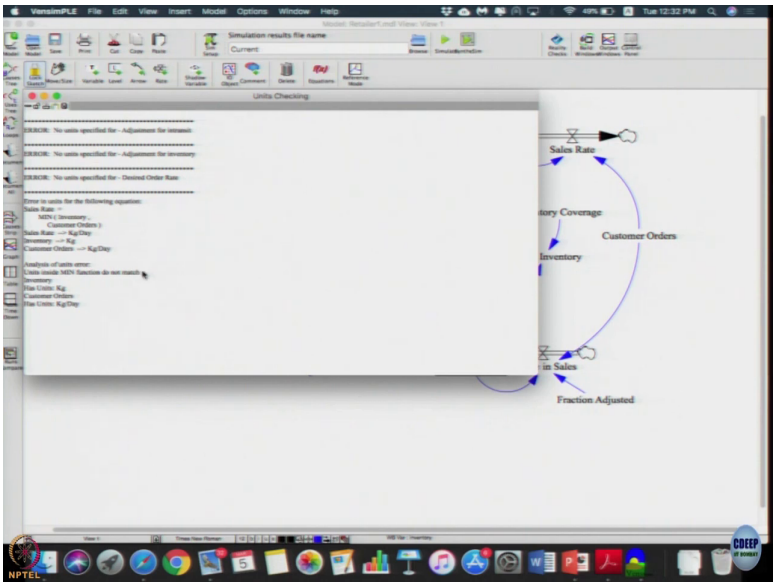

Adjustment of intransit etcetera I have not given, so let me do that. Model units check, these are the order, right, ok.

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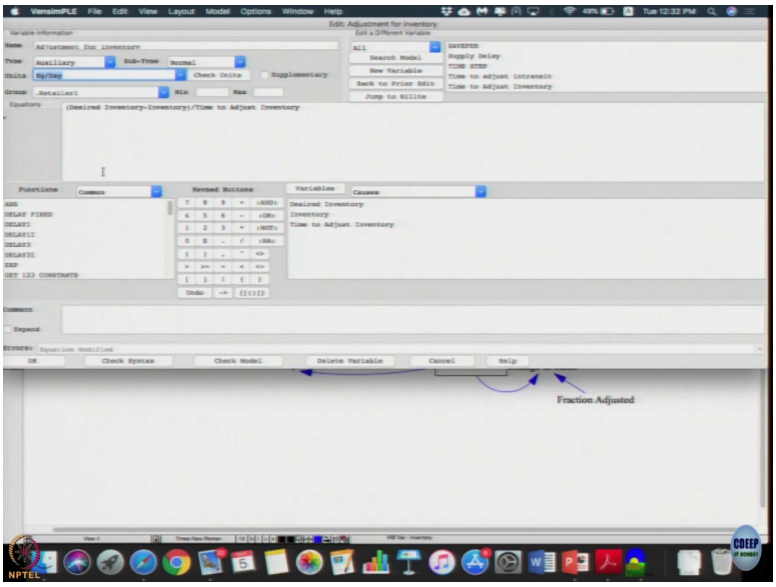

There will be unit's error for your minimum. Minimum we are comparing inventory and customer orders, customer orders kg per day, but inventory is kg. So, it is going to show an error for that. So, how do you fix it? How do you fix it? Unit's error means model is not correct. So, either we have valid model and invalid model, not much in between. How do you fix it?

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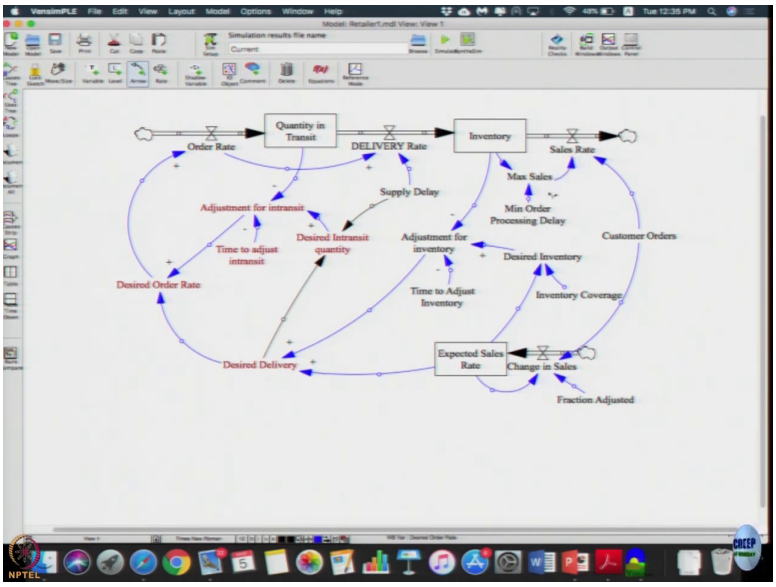

I can directly connect it. Let me call it, what should the equation for this be? How what will I connect it to? Inventory coverage is nothing to do with maximum you can sell. What is the maximum you can sell? Maximum you can sell is how much is the inventory and how much you can actually. So, it is affected by the inventory, good. But inventory is in kg and I want max sales in kg per day.

So, we introduce one more variable for time. Let us call it as a minimum order processing delay. Let me connect. So, let us say max sales is inventory divided by minimum order processing delay, let this be kg per day. Let the minimum order processing delay be 1 day, that whatever inventory have I can dispose it in same day. I do not have any issues in that. And sales rate, since of inventory let us call it max sales and customer order.

Now, if I do unit check I should not get any errors, all units are ok. So, simulate, I can get the actual inventory dynamics or inventory does not go below 0. We have got the average here, right.

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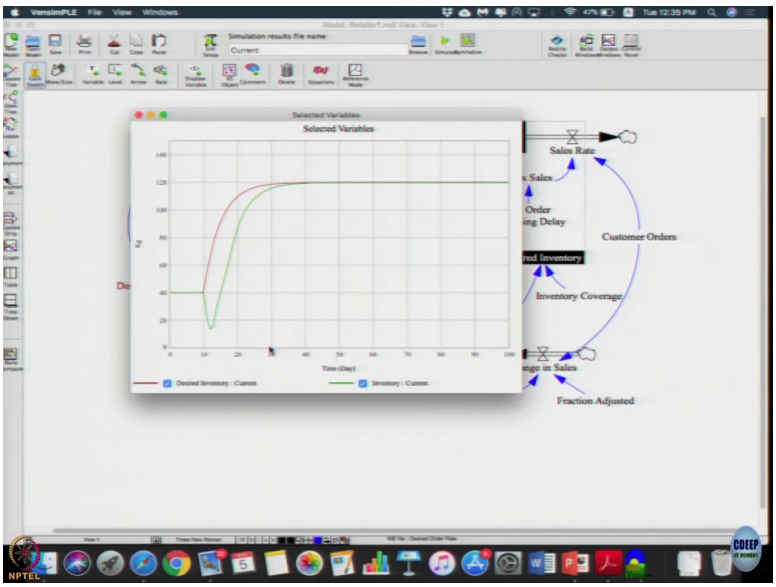

Now, this model is very close. First we started with the simple model to start how to adjust inventory, then we tried to include features in the model to better decision making and then we tried to include features in the model to make it little more realistic to capture what is actually happening within the scenario, like we do not want the inventory to go negative, because you are assuming it is going to be lost, so that as to be captured explicitly. In case it was not lost and if there is backlog, then we need to create a separate backlog unit. So, we will do it later.

Then we wanted to keep as less constants as possible, which can be directly computed. For example, we had a desired in transit inventory, but we got rid of it by using math. We had desired inventory, but since that is quite orbit we decided to map it to how much inventory coverage is needed is probably we can get more direct answer to rather than desired inventory you substituted that. So, we have only very few constants to start with, supply delays, inventory coverage and time to adjust inventories and intransit, customer orders and models kind of set for a particular edge law or the retailer. So, it is the model that we have right now. So, complete retailer model.

Start of the lecture, firstly I had at least talked about supply chain. So, let us at least move towards the supply chain, see how it is going to look.

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Till now you have model of the retailer. Let us suppose if distributor has exact same decision structure as retailer, I mean whatever distributor retailer is ordering it actually is a order goes to retailer distributor, distributor will then check his inventory and supply that to the retailer and in turn the distributor is going to order from say some factory up stream. Here in the only retailer model, what is assumed is whatever is order rate it is being provided by the distributor. There is no capacity on that.

Now, let us see if you are able to include a distributor model. So, this order rate will actually go to the distributor who will then check his inventory and then based on that we will provide the material to the retail. To do that, take a copy of your existing retailer model, go ahead or you can take a picture of it. First you have to copy it and do not do all the steps, you just try this read it once with me. Open that new file, set zoom to smaller size, then pretty much what we are going to do is instead of drawing the model again we are just going to copy the entire structure and paste it. So, that is I am just going to select all, this is a big sentence, but all I am doing is select all, copy, paste.

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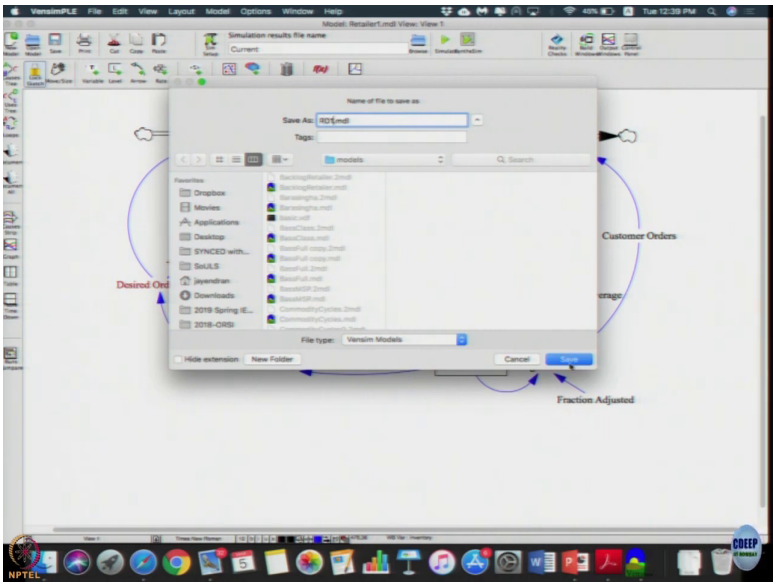

So, let us go for that file, save as. Let us call it as RD 1. You zoom 50 percent, too small. Take a (Refer Time: 11:22). So, click somewhere in the white area first, then select all, copy, when you paste, unfortunately you will paste right on top of it, so without clicking mouse anywhere else click on the black part, oh we will write here. You should be able to get this model. You got it.

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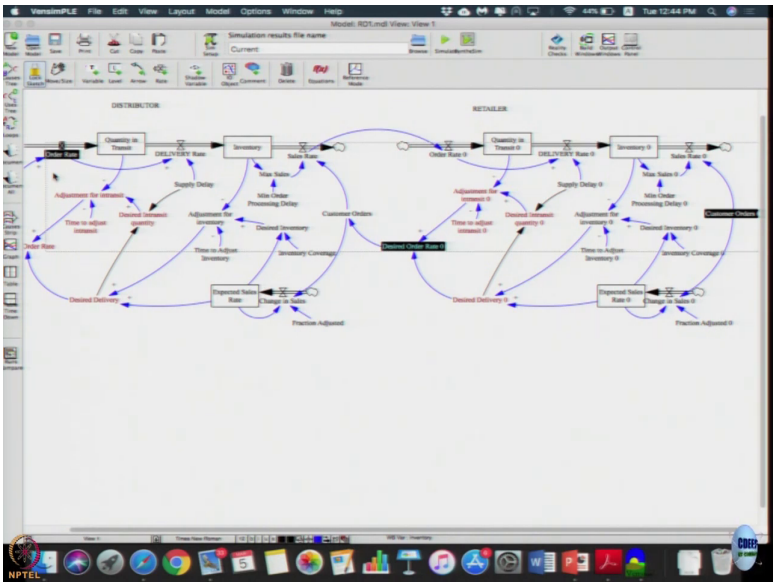

Please do it. See you will have one set of variables with the subscript 0, right. We have one set of variables in the right with subscript or a variable name with 0 in end of it, rather without the 0. To more times you copy paste you are going to get 0, 1, 2, 3, 4 or whatever that is what (Refer Time: 12:33) does. Ideally, we need to have proper names for each, but for now we will just go with this, we got these structure. So now, if you simulate it, it will still run all you have is two independent models build on the same screen, but still that dynamics will be completely independent, there is no relation. So, first we need to capture that.

For that, let us denote this for I am just adding a comment right in the top here saying. This is your distributor and this is your retailer, where just for more convenience what you now whom I am referring to. So, left side model is distributor for me and right side is a retailer. The one with subscript 0 is a retailer model, ok.

Now, for the distributor, distributor customer orders is not independent it actually comes from the retailer. So, let us add a link, arrow from desired order rate to customer orders. This is what he wants, so that is what he is going to order. Whatever he wants is what he is going to order. So may, customer order of distributor becomes equal to desired order rate. So I just added this link, ok. Now, I am to go ahead and delete this link, ok. So, desired order rate 0, customer orders equal to desired order rate 0. So, that is all I did.

Now, based on this customer orders sales rate will happen based on the max sales that is possible and whatever is sold is what is going to be dispatched. So, this order rate is nothing, but your dispatch rate. So, let us connect this sales rate with your order rate. This order rate is nothing but your sales rate. Only two links are here nothing else changed.

I am just saying whatever order came in he just gave distributor and distributor as a decision structure to follow and now sales rate whatever is sold it has to be passed on to the retailer. So, as soon as it is shift, so instead of sales rate you can call it a shipment rate if you want and this is your dispatch rate. So, this shipment rate should be equal to this shipment rate and instead of directly connecting them I am just connecting them as co-flows so, that we can physically see retailer model and distributor model separately.

Now, let us simulate we can check units, it is still match. Now, once simulated click on customer order is 0, desired order rate and order rate, just observe whatever as selected. Customer order rate is what the retailer end customer demand he faces that is the step function. Desired order rate is what the retailer order to the distributor, and this order rate on the left top is what the distributor is going to order to the his sub-stream player could be a factory or a warehouse or someone else.

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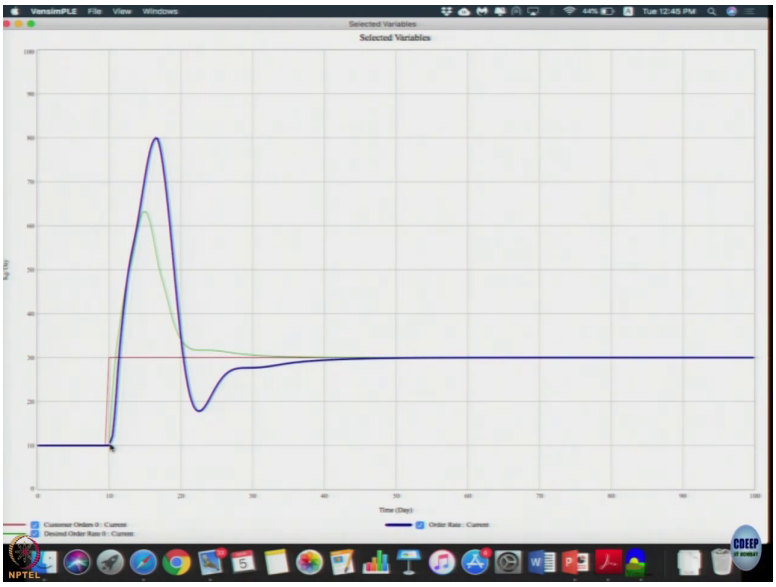

So, let us see the graph. Here we can nicely see that as a step change in the end customer demand. This desired order rate 0, there is the green line, yeah. Increases, and since distributor is ordering based on that we can see that the distributors order rate is actually much higher and exhibiting much higher dynamics during the model.

So, this was one of the basic ideas we started for us there to look at the to look at the dynamics as what we call is industrial dynamics and came in as book. And nowadays, we more popularly call this as the bullwhip effect that we have seen where any change in the end customer demand is getting amplified as we go higher up stream.

Any questions? It simulate your supply chain. So, now, imagine if you are adding more and more from this distributor, suppose there is another warehouse or there is a manufacturing and then there is another supplier and imagine dynamics is supplier is going to see because

each player is only looking at the information he is presented with. The distributor does not have any idea about the end customer demand. He is only seeing what the order is getting and he is reacting to that.

The decision policy is the same, the delays are the same, it takes exactly the same delays. So, for distributor also it took two days to supply, for manufacture for the retail also its taking two days, both their time to adjust inventory is the same, both are using the same exact same forecasting policy. Even if they have exactly identical players, still we are seeing this dynamics that is unfolding because of change in demand and just the shear presence of this multiple stocks and units which is further and further away from the end customer orders, which is right here. Any questions on this?

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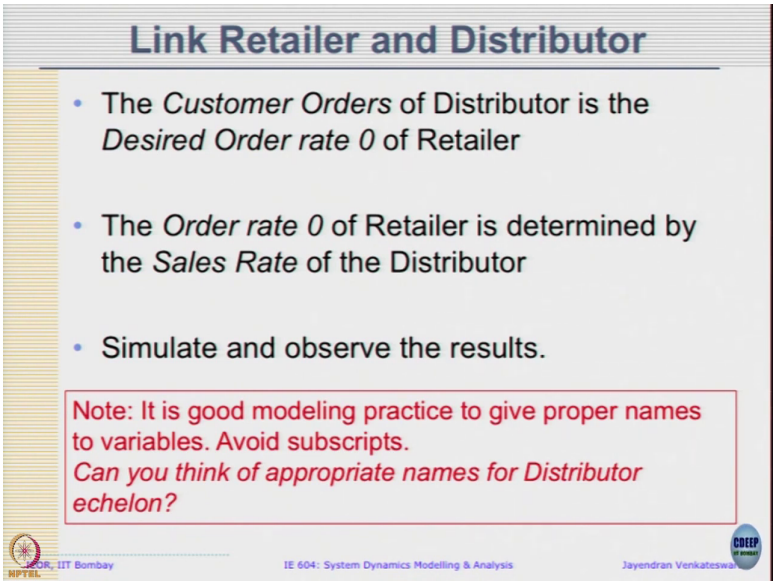

So, yeah. The only link we did was these two, customer order rate or distributor is a desired order rate 0 of retailer. Order rate 0 of retailer determined by sales rate of distributor, and we just simulated and observe.

It is a good modeling practice to do proper variable names and avoid all these subscripts. I just illustrated that now model can be copied and you can do it. So, you can think of appropriate names for distributor echelon, now you call a shipment rates instead of sales rate and you can call it supplier delay or something else.