Introduction to System Dynamics Modeling
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Lecture - 19.2
Stock Management Structure: Part II

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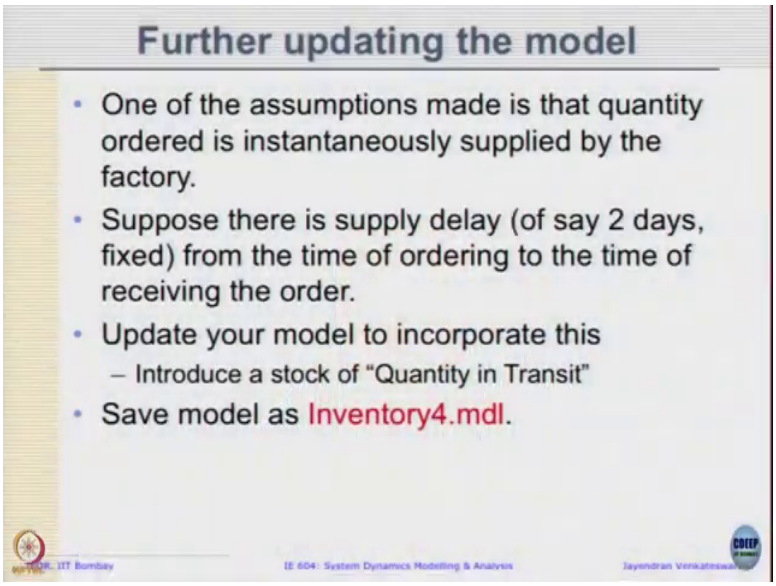

Let us further update the model, again we have been talking about retailer, we have been making one fundamental assumption in this; what is it? We are assuming leak time is 0. As soon as I order, end of the day I check the my sales; I check my desired unit is 200 kg's ok, today's sales is been 20 units extra. So, I immediately order and the next day morning it is there with us. So, that is the assumption that we have made. This instantaneously supplied by the factory or the distributor or whatever the source, warehouse or whatever you call it.

Now, let us introduce and see what to happened the dynamics when we explicitly account for this supply delay, right. Suppose there is a supply delay of say 2 days fixed delay, let us say there is 2 days delay fixed; from the time of ordering to the time of receiving the order. Now, let us update our model to represent this. How will we do that? What we need to introduce variable, flow, stocks what do you want to introduce? So, one of the simplest is; whenever there is such a physical flow of information, it is good to extract explicitly capturing it, right.

So, let us introduce a quantity called as Quantity in Transit. So, whenever you make an order, let it be in transit and after 2 days let it be delivered, ok. So, we will be introducing a new stock, as soon as we use the word there is a stock; that means, there as to be a flow that has to change it. And once the transit once the quantity in transit is delivered; that means the quantity in transit has to fall down, because it is already delivered, right. So, there is been inflow as well as an outflow to this stock.

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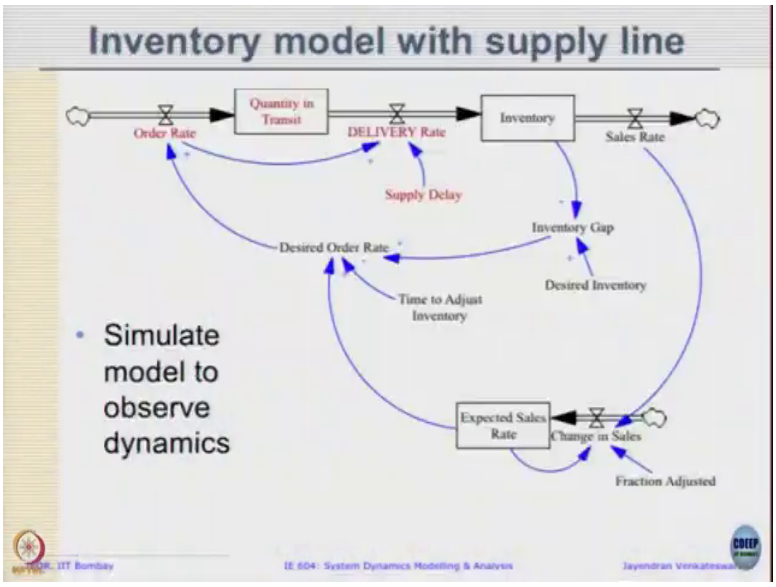

We will save it as. Now, let us why do not you model this; the red color ones are one you have to do, it will require you to delete some of your old model and then recreate this model. So, whatever you have done, you leave it; the red part you incorporate. So, all this model does is introduce a new stock; so as soon as desired order that became a order rate, it stays in transit for a supply delay of 2 days and then it gets delivered to the inventory, that is only think that we have added.

So, go ahead and delete your earlier order rate and redraw the diagram; only red ones is a new ones, others you should already have it. Order rate continues to remain equal to desired order rate. It is a fixed delay, how do we model it? Fixed delay of 2 days how do you model it? You need delay fixed equation; go into your model, use delay fixed and do the input as order rate, duration as supply delay, initial value as. Initially what should be delivery rate?

Is 0, initially sales rate is 0, so we will assume delivery rate is also 0; then initial quantity in transit will also be 0 So, first 5 days nothing happens. So, there is no reason why we should keep delivering, it is all 0.

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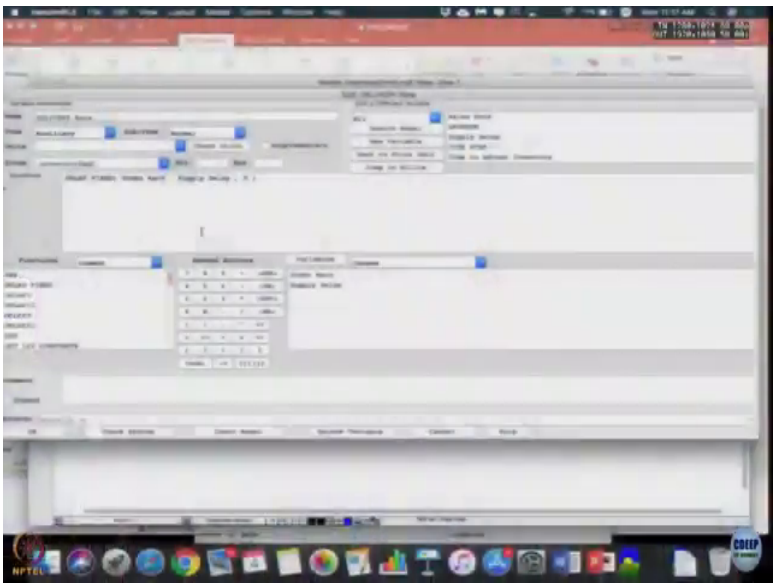

This is delivery delay; it is a delivery rate, delay fixed, order rate comma supply delay comma 0.

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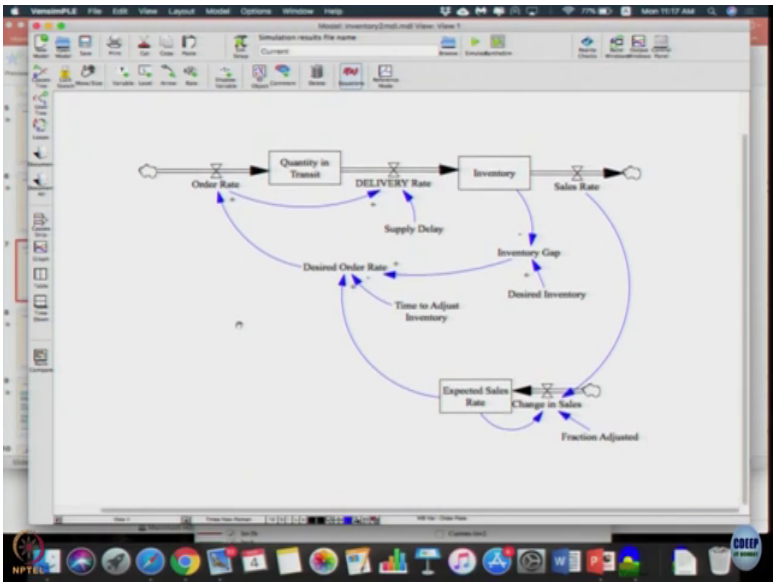

Got it, run the model; fraction adjusted or smoothing constant, check this model at using is to be 0.2. Now let us look at order rate.

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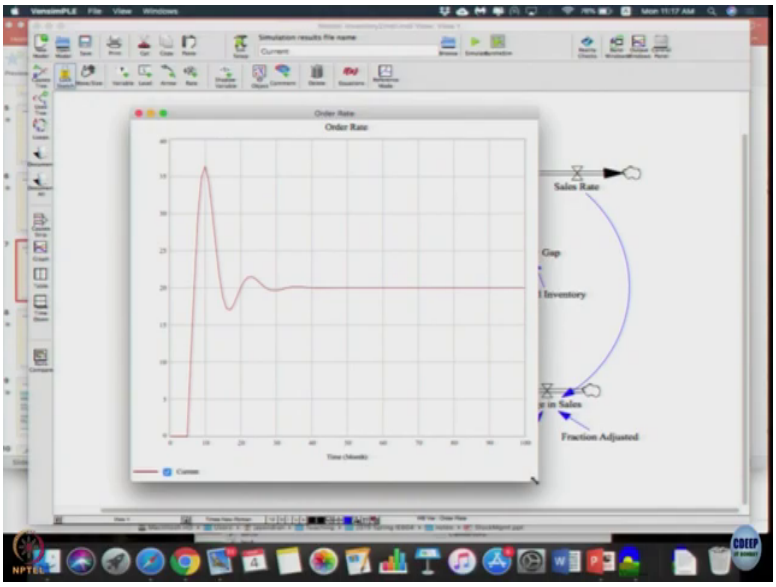

Now, we will start to see a pronounced oscillations within your dynamics of your order rate; earlier when there was only information delay, you over shot and then you gradually reached your goal. But when there is a supplied delay is all in supply in is also explicitly captured to represent this physical reality of the scenario, we find that there is oscillations. This we called as damped oscillations, so oscillation occur; but it just damps out and it reaches steady state of 20. If order rate is going to oscillate, quantity in transit 0; then it is starts to oscillate, inventory will oscillate.

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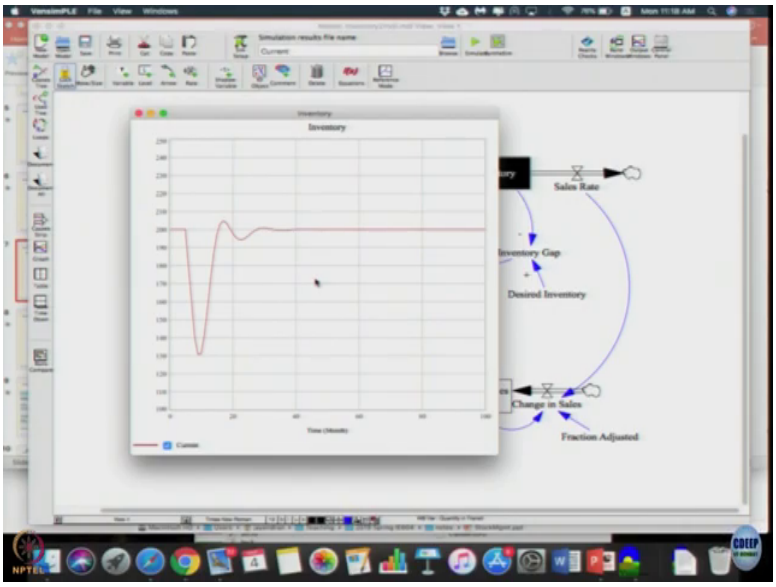

Initially it falls down, then it slowly oscillates around the mean or there around the desired value it oscillates and it reaches steady state. Sales rate will also oscillate? No it would not, it is exogenous variable.

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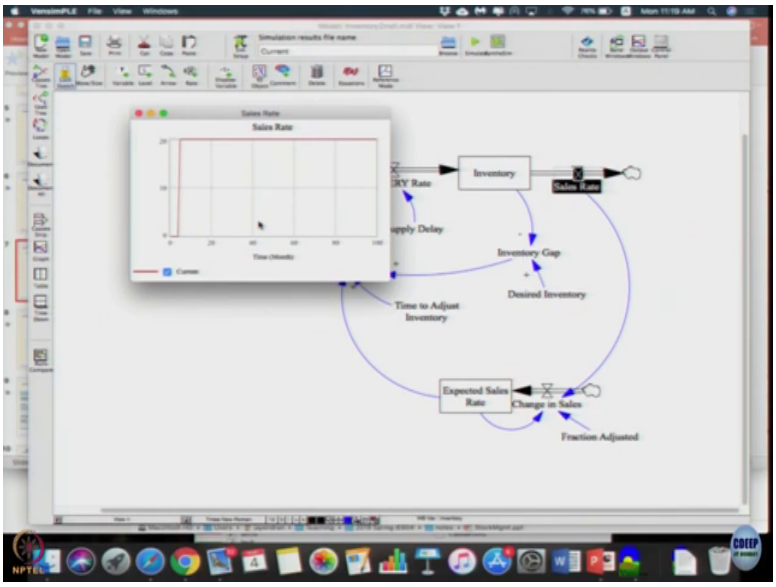

Why it is why should it oscillate; that should not oscillate, it is an exogenous variable, that is what drew drove the rest of system to oscillate. So, the important idea to understand here is, your sales rate is remaining constant from 0 to just 20 that is it, nothing else. And let us look at expected sales rate.

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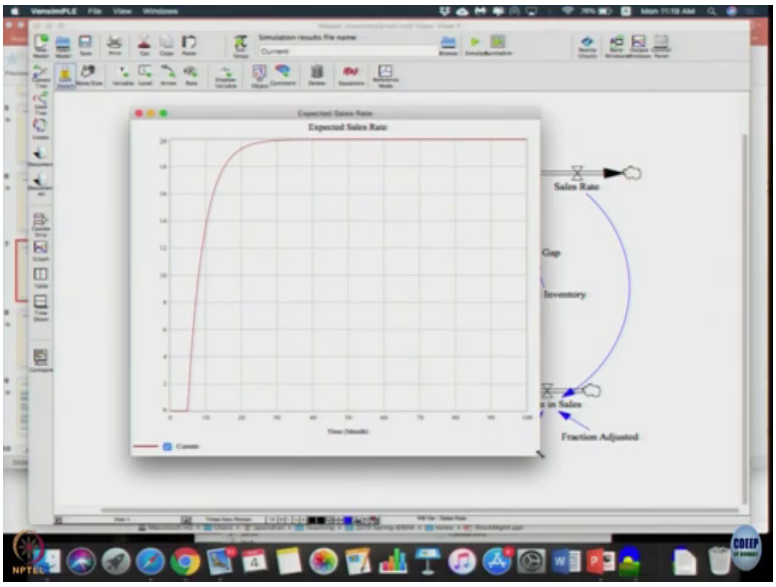

That also did not oscillate, expected sales rate had a nice exponential goal seeking behavior that also did not oscillate. But because of your ordering decisions, that is your entire decision that is captured here. So, the model can be divided into two; the top part of this stocks and flows can represent the physical stock flow model of physical flow versus the decision making structure that is employed by the retailer decision maker is represented using the variable like desired order rate and inventory gap and expected sales that is represent decision making structure.

That decision making structure of how we are adjusting for only the inventory gap as well as the expected sales rate is allowing us to, is causing the oscillation within the system, is causing the oscillations in inventory, order rate; expected sales rate does not oscillate, causing oscillation also in your order rate.

So, this is a very simple example of the origins of oscillations in business cycles, where why do you think it oscillated? The answer is here, we added this in the model, it started to oscillate, right. We add explicitly model quantity in transit, it started to oscillate, correct. It oscillated because, we failed to account for this supply line in our decision making; though physically the supply line was model, we never use the information in our future decisions.

We ordered something today, I know it is going to come after 2 days; but the next day immediately look only at the inventory, then you could decide inventory, the gap is large ok, let me again order and the let me again order. So, result happened is that, initial orders over shot more than what you actually need; because initially the gap will keep widening, because it takes 2 days for it to come. You saw that short fall of 20, immediately order 20; then next day the short fall became 40, because whatever we ordered is 20, took to will take 2 days to come, it has not yet reached.

So, gap became 40, you ordered 40 units. So, it over short, what you more than the desired or steady state order value; and then when the quantity started getting delivered, you suddenly realize that 20 got delivered let me order less. But then the next week 40 got delivered, 3 weeks since, right. So, the inventory over short what it should have been? So, immediately start to cut down the orders; lower than the steady state order, so that resulting in the order quantity going below the steady state values.

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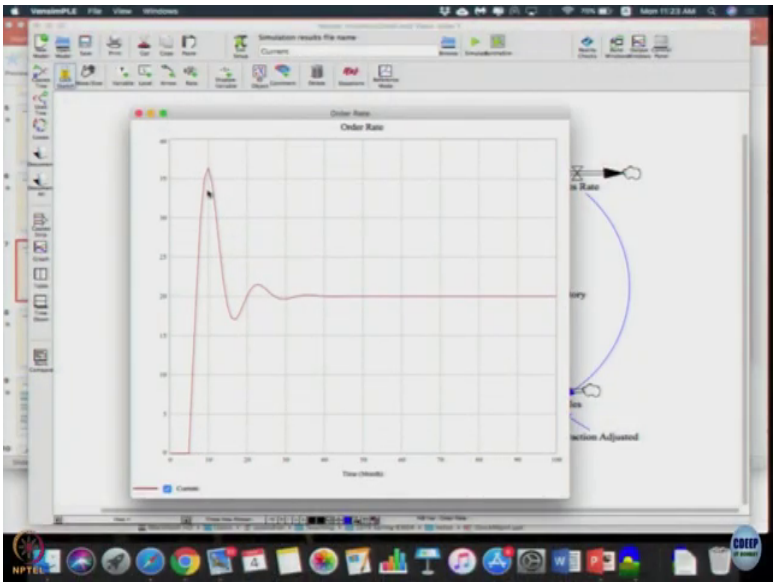

These are represented in this graphs, right. So, initially over compensated, that is every time we only looked the inventory value and making decisions; you did not account for the supply line within the system in making your decisions.

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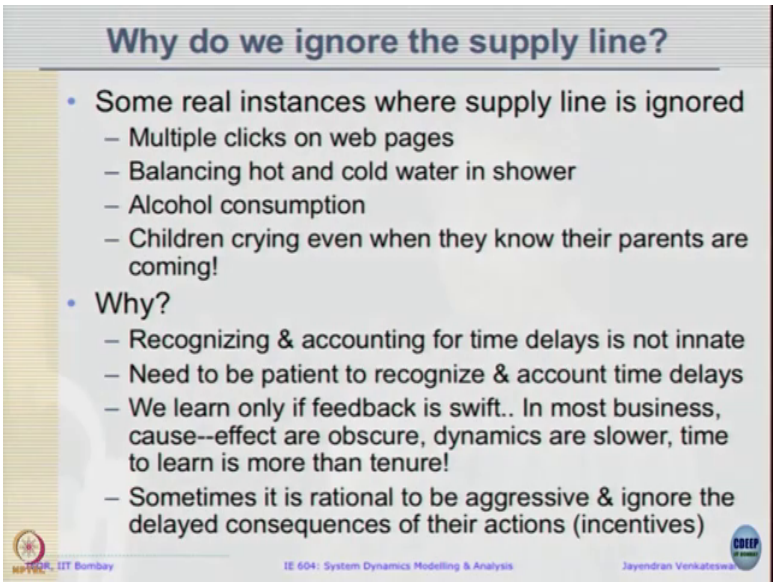

Why do we ignore the supply line? Well it is difficult to account for it, frankly speaking. When talked about logically it seems; we should account for it, yes it is so obvious. If you already made an order, I would not make an order again right, we do not make an order again; because I order, no retailer is going to order, forget whatever we ordered yesterday, because he is going to get it later that is the rational explanation.

But there are several real life scenarios, where we may tend to ignore the supply line. For example, multiple clicks on web pages if it does not load, you keep refreshing many times. If you refresh it once it will come; but you still refresh it many times, that is all goes to supply line and suddenly you find there website refreshing 2 3 times, it is all getting piled up.

Balancing hot and cold water in the shower, especially if it is in new place, it take some time to get used to it; may be in your home or in your hostel or somewhere, you know exactly

where to change the dial. But if the new place you do not know where to set it, you set it in; there will be a cold water in the pipe, it has to come down come out right, but then you make it really warm, then suddenly you get lot of warm water, then again you close it. So, that is because you did not account for a supply line, because the information is not available to you to make the decision.

Why do we ignore supply line? Because recognizing and accounting for time delays is not at all innate. We are used to taking short term and very quick feedbacks; we do not account for very long term effect that can occur. We look at what is happening now that is the inventory kind of thing. Now, this what is happening ok, let me take a decision right now; we do not care about what is in the stock, what comes later things like that.

We need to be patient recognition and account for time delays; so you may say like you know in our hostels and homes, we are used to we know where to set the hot water, cold water dial, or our current retailers will know exactly where to set for his how much to order, how much when to order. But whenever new settings, new products come in, people have failed to account for it; especially when there is a disruption in this supply, they just cannot account for it.

We will learn only if the feedback is swift. In most business cause and effects is obscure; and supply is need not only be cause by you right, there will be so many other retailers ordering, so many other manufacturers supplying, so all those things are also going to affect it. So, which obscures your cause and effect scenario, when dynamics are slower and time to learn is more than the tenure. Sometimes he is the regional manager only for 2, 3 years, right.

If some feedback is going to come kick in after 3 years, you do not really care; because or your term is over, but this 3 months is you had a objective, the marketing manager objective, so he has to fulfill that in this 3 months, in this quarter. Say any feedback may occur in the next quarter, you will say I will worry about it in next quarter; but that means that, what he is doing is he ignoring the supply line.

Sometimes he is rational to be aggressive ignore the delayed consequences; like we are just told about the incentives, you have incentive to only look at this month sales target and accordingly take a call. This months inventory level and take a call on what you should do, rather than what is in the pipeline, what might happen in future.

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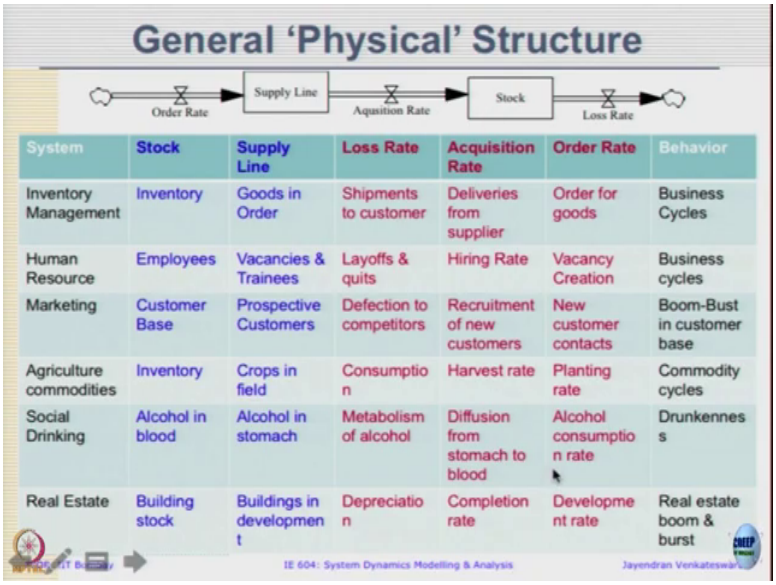

System	Stock	Supply Line	Loss Rate	Acquisition Rate	Order Rate	Behavior
Inventory Management	Inventory	Goods in Order	Shipments to customer	Deliveries from supplier	Order for goods	Business Cycles
Human Resource	Employees	Vacancies & Trainees	Layoffs & quits	Hiring Rate	Vacancy Creation	Business cycles
Marketing	Customer Base	Prospective Customers	Defection to competitors	Recruitment of new customers	New customer contacts	Boom-Bust in customer base
Agriculture commodities	Inventory	Crops in field	Consumption	Harvest rate	Planting rate	Commodity cycles
Social Drinking	Alcohol in blood	Alcohol in stomach	Metabolism of alcohol	Diffusion from stomach to blood	Alcohol consumption rate	Drunkenness
Real Estate	Building stock	Buildings in development	Depreciation	Completion rate	Development rate	Real estate boom & burst

So, general structure of the physical structure of the flow can be simply modeled as an order rate and then there is something in the supply line and then acquisition rate, which affects the stock and then there is a loss rate. Most often we are used to seeing the stock to make the decision based on the loss rate. What is difficult is to capture the supply line is very difficult to capture. We are looking at the stock and the loss rate and taking it look at the order rate without accounting for supply line or acquisition rate.

This can be mapped into variety of scenarios the structure that we are going to discuss or we have been discussing. Like inventory management what we are doing; the stock is called as inventory, the supply is goods in order, loss rate is shipments to customers, acquisition rate is delivery from supplier, order rate it goods on order, the behavior is called as business cycles that is what we have been seeing.

The similar model can be applied for even human resources; whereas, stock rate is nothing but employees, supply line is your vacancies and trainees are there in the system; your loss rate is nothing but your layoffs and quits. So, based on that I need to hire people; whether as soon as you hire, they are not ready immediately available, we need to train them, we need to give a job offer, people has to join and then they will go through some induction program and then you have to select and become part of the team, therefore there is a huge supply line gap.

So, this is also part of business cycles. Even marketing this is applicable, where we will look at customer bases as your stock, potential customers as supply line and we customers can defect to the competitors, then you have to recruit new customers, and as new customers come in that is the whom you are going to work with. So, that is called as boom bust in customer cycles.

Agriculture commodities also similar structures applicable; where inventory is inventory of the grains or food, supply line is nothing but a crops in field and your consumption is your loss rate, acquisition is harvest rate, and order is a planting rate. So, this fundamental structure can be used to somewhat explain the agriculture commodities cycle, where some commodities you get a huge overstock and prices just crash and government has to you know rescue them.

Because, people looked at there is a lot of demand now, so let me plant more and then they forget that they have planted more and suddenly you have huge amount of stock coming in and then price. So, there are other dynamics like price, but the fundamental idea remains the same. Then real estate building stock we have, buildings under development is a supply line

and when buildings depreciate, that is a loss rate completion rate adds new buildings to the stock, development rate adds to your supply line.

So, this results in real estate boom and bust, where multiple players are building lot of buildings. But based on the current demand new and new developers come into play, result is total building stock increases, then price goes down, then they again hold; because they are not really worried about this supply line, we just keep building.