Decision Making Under Uncertainty
Prof. Natarajan Gautam
Department of Industrial and Systems Engineering
Texas A & M University, USA

Lecture - 21
Buffers to Cushion for Fluctuations

The topic of our lecture is called Buffers to Cushion for Fluctuations. Now uncertainty, risk, variability are different ways of explaining things that you did not expect to happen. So, how do you go about managing when there is that kind of fluctuations and we are going to use what is called buffers to cushion for fluctuations. Now, this is a topic that is from the book- Factory Physics by Wally Harp and Mark Spearman. I would recommend reading that, it is a wonderful way of describing how some of this is done.

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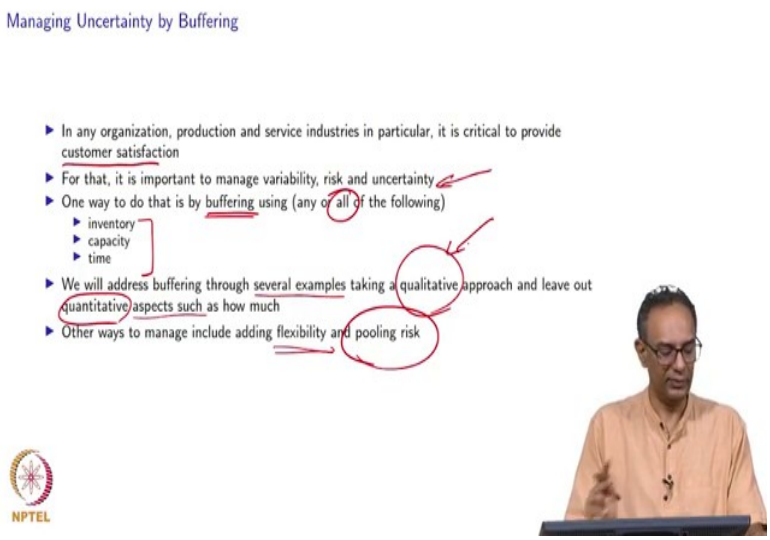

Now, how do you manage uncertainty by buffering? So, if you think about any company whether they are in production or they are in service industry; they are striving to provide what is called customer satisfaction. So, that is the most important thing for most companies because providing customer satisfaction directly hits the bottom line of making profits.

Now, to do that one has to know how to manage variability, risk, uncertainty; whatever you want to call that- things that you did not expect, things that you did not foresee or you know things that were not according to forecast. So, how do you go about managing those situations? Now, one way to do that is by what is called buffering.

And we could do a combination of carrying inventory, having spare capacity, or even relieving capacity and also by buffering by time. This may not be obvious; next we will show you five examples and I will explain this a little bit well. However, we more often than not, do a combination. We probably do all of them for the most part, or any subset of them is what many times organizations are involved in.

So, we will do several examples and I am going to take a qualitative approach. I am not going to be quantitative. We will talk about the quantitative stuff later in the next lecture. However, in this lecture we are going to mainly be touching upon qualitative aspects. And we will not say anything about quantitative stuff such as how much buffer to carry; we are not going to answer that question in this lecture. We are just going to answer: what to do for buffering?

Now, there are other things that one does to manage risk, and uncertainty and variability and that is to add flexibility. We will see examples of that as well; you do not call those a buffer. So, these are not buffers, this is just having very different flexibilities like a machine that can produce multiple things, like a numerical control machine. The CNC machine can do many different things so that that adds flexibility to shops. Or instead of buying a separate machine to do milling and drilling and machining, you might as well do have three of them.

I am sorry you have might as well have one CNC machine, which really offers flexibility or you buy three CNC machines it could do some day all three milling and so on so that is what it is called flexibility.

You could also pool the risk. There could be risky things happening in different situations and I will look at few examples later and it is possible to pool some of those risks together and thereby reducing. So, if you think about it, it is kind of like the effect of the central limit theorem, where you have a bunch of independent random variables. And if you pull them together, turns out that you know some of them will be higher, some of them will be lower.

So, on an aggregate level, you will actually reduce the variability and that is an important thing to consider. So, that is the technical details behind all this, but from now onwards our approach will be purely qualitative like I said. And we will not talk too much about the quantitative aspects.

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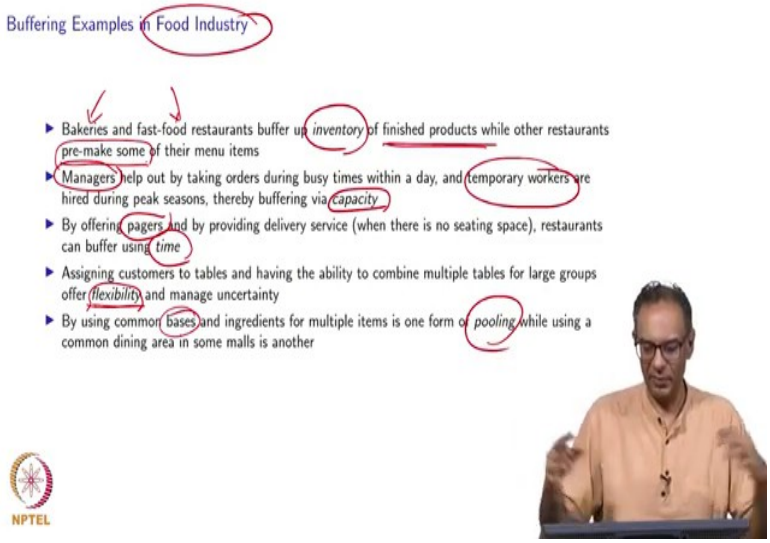

So, let us look at the first example, which is a food industry: this is my favourite industry given how much I like food. So, I guess for most people. Turns out that, if you look at things like the bakeries and fast food places this is again perishable items like we saw in the previous lecture. People typically carry some inventory of finished products like this is. So, you do not know your demand and you are also not sure as to how much therefore to carry. What should be the cue?

Now, turns out that if you ordered enough so that your demand is satisfied and you might have an inventory maybe a little bit more or a little bit less depending on how your variability of your demand looks like. However, if this situation is even beyond that: what if you suddenly got a surge of demand that was a little bit unusual. For example, let us say it is a special time of the year and there are a lot of people visiting; all of a sudden you get an unusually high demand.

So, you might carry a little bit of inventory, so this is buffering by inventory. You could also do something like a lot of fast food restaurants- actually carry pre-made stuff; they actually keep it out there. So, that you know they could go ahead and get those items instead of ordering and waiting for the items to come; so this is clearly improving what we call as customer satisfaction.

Other restaurants also pre-make their food, it is not that everybody starts from scratch like you are cooking in your house. They pre-make a lot of items and that is why in many

restaurants you have a menu card. Because they can pre-make a lot of these things. They do not just create stuff on the fly. Of course, they do finish of items and that is why you could do some customization; now that is the inventory.

The second type is what is called capacity. So, many times you know managers help out by taking orders. You see this all the time in restaurants. Because all the waiters are busy helping other customers and then you are thinking the manager looks and so all the waiters are busy and there is a table that you know people are waiting to hear about the menu and so on.

The manager runs up and says here is the menu ma'am: "can you please go ahead and take a look and one of someone else will come and take your order in a little while". So, it is important that people help out and thereby increasing the actual capacity than what is available. Sometimes during holiday periods, during peak seasons and so on you would hire temporary workers to come and work in your restaurants. So, that is very common; in this way you can increase the capacity very nicely.

Another thing that you can do is- you could buffer by time and how do you do that? Well if your restaurant is full, you will be give pagers. These are these little devices that you hold and light up, when you have a table ready. It gives them that and then tell them to go. The other thing that some places do is to tell you: "oh I am really sorry! Would you be happy to take a delivery service"? We will offer free delivery service; so you stay at home. So, let us say you call them and say: "do you have a room for a party of 6", and we go, "oh! I am really sorry we do not", but if you give me an order I will come and deliver it for you. Of course, it takes a little bit of time and that is why you are buffering buy time.

So, if you are postponing a request that is buffering by time. If you are anticipating requests and carrying inventory that is buffering by inventory. And thirdly, if you are increasing your service capability that is called buffering by capacity. These are the three common ways that one buffers. Besides that, you can also do what is called flexibility and we talked about that earlier.

So, you could do things like having some general purpose tables and you could do clever assignments of tables. Say for example, a party of two comes and you probably will not put them in a table of where there are four seats. On the other hand, if you had a party of eight, you will not have a table with eight because a party of eight is sometimes very rare in a restaurant.

So, what you would do is- you would just configure your tables such that you have mix two tables of four together, and put them together and create a table of eight. So, this is what we call as flexibility. So, you manage your variability and uncertainty using flexible systems- things that could work for both a small size as well as a large size.

Now, another thing that lot of restaurants do; I am sorry if you get too excited about this. Most restaurants are rough using common basis, they have the same ingredients, and then they mix them up depending on what you would like to eat; that is a way of pooling risk. So, you do not want to make too much of something in particular; remember I told you a little bit about going ahead and pre-make. You do not pre-make so much. The smarter thing to do is to have some common ingredients and then use those common ingredients in order to you know make some of your items.

So, that is called pooling. So, you are pooling a bunch of resources together making a lot of that so that you know suddenly if you request more of one particular item, then you do not have to make that, but you could you could manage the risk by pooling.

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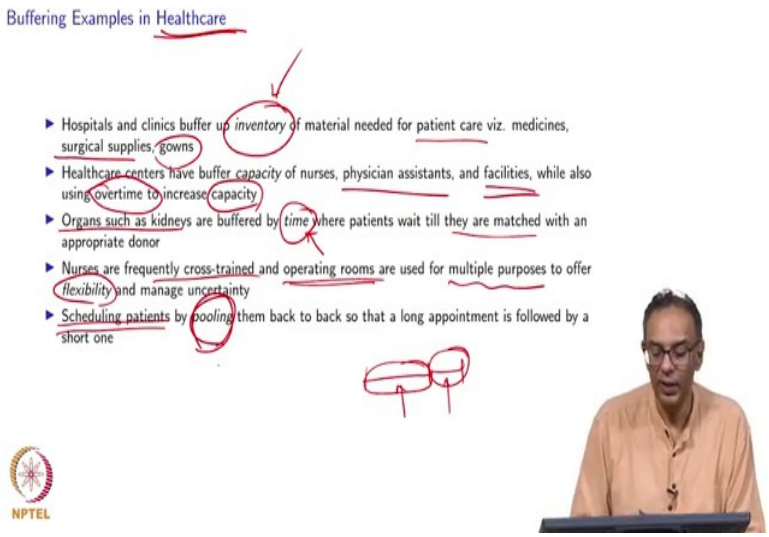

Next, let us look at health care. We have all been to some type of hospital or the other. And they usually buffer inventory of patient care material. For example, the pharmacy in the hospital will typically have a bunch of medicines. They are not going to run looking for a medicine all the time. Whenever you know they not only have just enough to meet the demand, but they will carry a little bit more.

So that in case a few more patients happen to come, they will have some medicines in stock. However, you have to be careful- medicines do expire! So, therefore, you do not carry a whole lot of inventory. So, you need to know how much to carry, that is why this is pure qualitative explanation. But, a harder question is how much to carry because these things expire. You could also have surgical supplies, and you do not want a doctor performing a surgery and realizing- "oh goodness I do not have these gloves that I need".

Any type of surgical supplies we will typically be carried in large numbers. In fact, they have automated systems that would remind you to go and buy more, once you start exhausting. But still you know, to suddenly take care of a surge of demand, you typically have a lot of supply sitting out there. You do not want a patient to come there and say: "oh! We ran out of gowns; we cannot perform the surgery". It costs a lot of money to schedule a surgery. So to manage the uncertainty, you typically carry a little bit excess number of gowns than what you typically would need on a regular day. So, this is a way to carry inventory. However, there is always a cost for carrying inventory, you have to be a little bit careful about it.

Another thing is to increase capacity, and very often hospitals do this and let us say there are nurses. You typically have a few extra ones so that in case we get a large number of patients or lot of help is needed for some patients, you always need to have a few extra ones. So many hospitals; although nurses are hard to get, many hospitals end up having a few extra ones. So that, just in case you know you need a few.

They also have physician assistants. Let us say the actual doctor is not able to come, maybe because they are themselves unwell, then a physician assistant steps in. So, any of those types of uncertainty, you do have other people that can care for the patients. You also have buffer, or you can also increase capacity by having facilities that have extra space in them. Like you know- a lot more like operating rooms. Unlikely, but at least one extra one than what you typically need.

So, the other thing is that doctors, nurses work overtime to increase capacity. Because let us say you want to take care of all your patients for that day and you are not able to do it during the working hours, you will go ahead and increase capacity and thereby by doing what we call as over times. Another example is you could buffer by time, this is rare in a healthcare situation except for example, let us say we are talking about storing blood or storing kidneys and so on.

Again blood is still stored as inventory, but kidneys are not. For example, you will not have a kidney sitting there. It is such a precious item that people we will typically wait. So, if somebody needs a kidney transplant, they will wait. So, you buffered by time because you would never keep such as precious organ as an inventory. You will always tell someone, who needs it; put them on a waitlist and whenever they get a chance they will be matched.

Now, turns out that there is a lot of flexibility in the healthcare industry. Nurses typically are cross-trained. So, you know a particular nurse can help carry out various types of care. For example, they could take care of patients that have you know different types of diseases. Just so that, wherever there is a sudden urgent need and they could do that versus what they usually do.

The other thing is operating rooms, many times are used for multiple purposes. But recently, I was familiar with a situation where you know they took the paediatric ward, where babies are born and kind of combined it with surgeries that take out the uterus- called hysterectomy. They put the patients of both in similar rooms. So, that the situation is somewhat similar, the care is somewhat similar on hysterectomy situation; you do not have a baby in there. However, in terms of the care of the mother in either case is similar. So, it makes sense to have multipurpose rooms for that; that is the way to manage uncertainty.

Now, you do a lot of pooling. Pooling is very interesting and there are many ways, and scheduling patients in healthcare is an interesting topic by itself. People have written papers and papers; it is a very interesting problem. However, to give you a very quick way- how you would like to do scheduling is, you typically do back to back scheduling such that you put down one patient, who has a chance of going over their time limit with somebody who has a good chance of being under.

So, for example, you typically give- let us say half an hour appointments to each patient. Then you would put one patient at 11 o' clock in the morning, and the next patient at 11:30. You want to be sure that you do not put two patients, who can possibly go well over the half an hour limit. In which case what will happen is- you start getting a cascading effect and it will be a big problem. Instead what you do is you pair up patients so that one person is probably going to be lesser, the other person going to be greater. This is a way that you pool some of the risk associated with scheduling.

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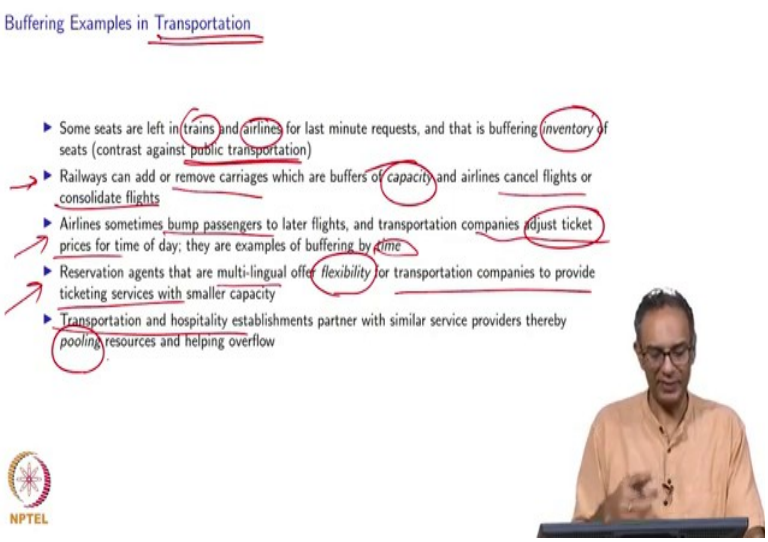

Let us now move on to the next example of transportation. So, there is a lot of uncertainty in transportation and typically if you look at trains and airplanes there are some seats that are typically kept for last minute- it is called *tatkal* in India. And these are last minute requests; you typically keep a few seats so that if somebody needs urgently, you get that. That is typically what we call a buffering for inventory.

Now, public transportation for example, typically do not have that because there is always another bus; you could always do buffering by time. If there is no space in a bus or space in a suburban train, you normally do not worry about it. You do not typically have these stacks, you do not even have reservation for the most part. Another thing that railways do a lot of is: they add and remove carriages.

Let us let us say for example, there is a peak season. Based on how everybody is travelling, they immediately would add a few carriages and that thereby increase in the capacity. In fact, it could go the other direction: airlines frequently cancel flights and consolidate flights.

So for example, if there is a flight from say: Chennai to Mumbai such that there are two flights one at 10 o' clock and one at 11 o' clock; sometimes what they would do is they would just consolidate those two flights and put them as one, or they would even cancel one of the flights and just move the move the passengers to the next flight; this happens a lot.

Airlines do one other thing a lot, which is they bump passengers because they overbooked flights sometimes when there are too many people requesting- they bump the passengers and then they ask them to go later. So, that is buffering by time; typically we also do adjustment of ticket prices for times.

Now, adjusting for ticket prices is actually a combination in fact, ticket prices- this is a very interesting concept or companies like Uber for example, have this differential pricing and depending on the time of the day they would adjust the price. So for example: they do not have enough drivers, they will jack up the price. So, that people looking at it: Oh! I do not want to go look for an Uber vehicle. Basically what you are doing here is- you are actually, we did not talk about you know pricing as a means for taking care of this kind of uncertainty; that is also one thing. So, this is a combination by adjusting ticket prices- by just adjusting fares, you are buffering both by time as well as by pricing. So, that is another way of doing the same thing.

Now turns out that reservation agents can be what we call multilingual. They can speak two language: they can speak English and perhaps another language, and they offer flexibility. This way for example, let us say there is one person, who can speak both English and Hindi and there are they can cater to customers who are English speaking and Hindi speaking. That is better perhaps than having separate reservation agents, who can only speak English or those that can only speak Hindi.

And thereby you know you are looking at this inflexible system, where one let us say becomes too full and there are no one who can answer your questions, you put the person on hold, which was something that we do not want to do for improving customer satisfaction. Now, also transportation companies are benefitting by that because they really have to have fewer people in the ticketing agency by carrying a smaller capacity.

So in fact, flexibility here improves the capacity. Another thing a clubbing transportation and hospitality industries. Doing hospitality means hotels- it typically could be rental cars and people like that. They provide a lot of pooling. For example, let us say all the rooms in a hotel is booked, we have had to do that very recently; a hotel was completely full, they would call a another hotel nearby and say hey we have a bunch of extra people, can you help us out?

So, these hotels help each other out so that once they get full, they transfer their customers to another hotel. So, this is essentially pooling resource- it is like having a chain of hotels or

chain of places that people can actually book and get served. So, that is typically another example.

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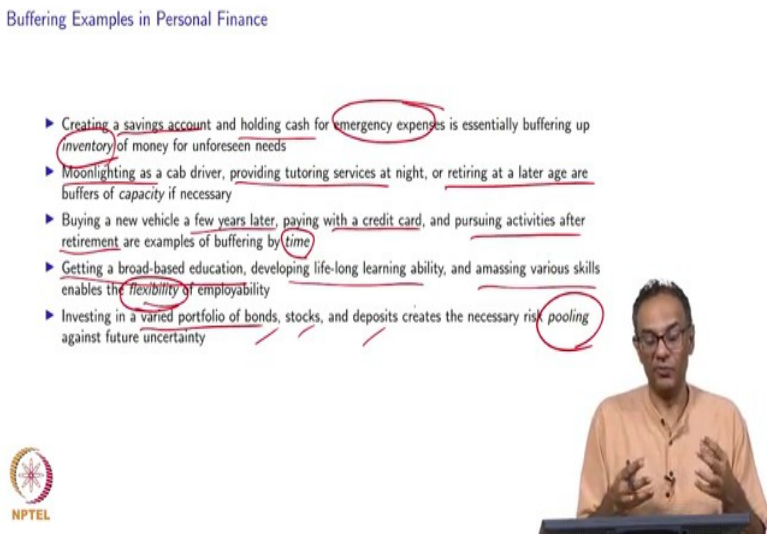

Next example, I like to talk about what is called personal finance. This is somewhat of an unusual example. The previous three has been researched a lot, this one I threw it in on just to talk about some of personal situations; all of us have been in these situations. It turns out, we have what is called a savings account where we hold some money. We even can hold cash in our houses, this is for emergency expenses; we all do that.

Why do we save? So that we want to be sure that we have money not just after we retire, but also when we have some incidental expenses or emergency expenses for some unforeseen unfortunately. So, that is a way to buffer for inventory. Now, you could also do capacity. For example, you could do moonlight as a cab driver; this happens a lot in the US, where people who have an Uber; they could be an Uber driver at night and they could be working in their day jobs. This happens a lot and that way they are actually increasing their capacity to earn. Some people provide like tutoring services in the night, again you know working two shifts and thereby improving their ability to earn. Some people retire at a later rate; that is another way to improve the capacity.

So, if you want to stock up, you retire a little bit late- you have decent amount of money, well you retire. Another way is to buffer by time. This is a little bit unusual, but thinking about it- I want a new vehicle, but maybe I will buy it a few years later. So, postponing that decision is

buffering by time. You could also pay by credit card- let us say you are waiting for your pay check to come and you don't even have money to pay for something, you pay with a credit card and then later once the pay check comes, you go ahead and pay the credit card company.

So, we will sometimes pursue activities after retirement. So, something I really want to do, but I do not have that kind of time right now to take a long vacation to go around the world. You might say: I might do that after I retire. So, that is the way of buffering by time. So, these are things that you could do; although the retirement stuff does not seem like an urgent emergency type situation. Turns out that for some reason you are saying: "ok, I really planned this, but something urgent came that is kind of what I was thinking".

You know you planned a wonderful vacation, but something urgent came up and you had to cancel it and then say: "I will put it off for a later time in life". Now, there is also flexibility, now this is an important thing; this is looks more like advice that I am giving. Yes, it is important to get a broad-based education. So, that you know if one type of a job description is no longer needed, you could get a job in another company; gives you that flexibility. It also gives you a lot of flexibility if you have the ability to do lifelong learning.

So, let us say tomorrow nobody is using the software called octave; you should have the ability to learn the new software that becomes popular. That is what I meant by lifelong learning; that is something that gives you a lot of flexibility of employability. And also getting a large number of different skills is also very useful, maybe one skill is not useful, right. In the future you could you could still get a job because you have the ability to go and do different things.

Now, another way is to pool and this is done a lot especially those of us that are into investing, you would invest in a bunch of different stocks. So, that if one stock goes up the other goes down or something like that, you are not stuck with a negative amount of money in your balance. So, to be careful, what you do is- you actually pool your real risks and the other thing you do is- you also get bonds, as well as stocks, as well as you know certificate of deposits. This way you kind of diversify your portfolio as they say, and this is also called pooling your resources.

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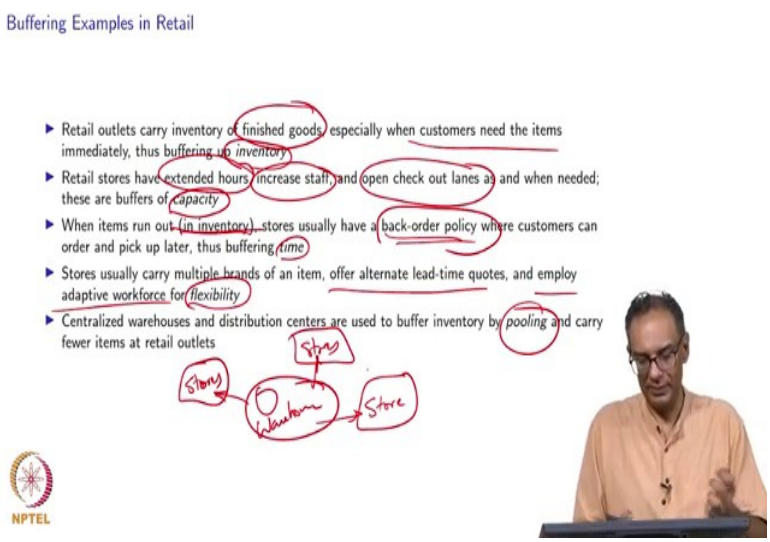

Next example is in retail- by retail we mean stores that carry clothes. For example, let us say you have a clothing store- that is an example of a retail store. So, typically they carry inventory of finished goods and whenever a customer needs the item, they typically have it in inventory. So, for example, you go to a store, you typically find the shirt that you want or the pants that you want because they typically have an inventory of those items.

And the way that these retail outlets manages to carry enough amount of inventory; usually you ask the question: “do you have some of this in the back”? Yeah, they typically do. They go pull out a shoe from the back because they do not want to display everything; there is not enough space, they will keep some hidden inside. They are not actually hiding anything; it is just because they do not have enough space.

But, by carrying items in an inventory they could manage the variability and uncertainty. Another thing they do is they do capacity planning especially in grocery stores and so on. You often times see, where the hours you know- the open checkout lines for example, they have extended hours during some time periods. They also increase staff. So, you may have seen this sometimes- some of the lanes are closed and once the queues become a little long they say: Ok, let us improve our customer service, let us open a few lines and then a few lines are open; typically a manager comes in and helps out and things like that.

So, that is the way to improve your capacity. You could also buffer by time. So, if you cannot have inventory; if inventory runs out, typically you have what is called back-orders. You say: "ok, sorry we do not have it today, but I will have one delivered to you in a week".

If you remember from two topics ago, we talked about a company- Dell, it actually always orders this what is called as back-order. That means once you say what you want, it will actually put together a computer and then give it you. You could also do some type of back-order, you have this all the times when we go to *amazon.com*, you click, it will say: well we have your order stock. We will come back later, order stock is essentially saying- you buy now, but will give it to you later. So, that is buffering by time.

Now, there is also this notion of flexibility. A lot of companies especially retail stores carry different brands. You go there thinking I want this particular brand and then they say: well we have run out of this, but we have another brand. So, by offering multiple various options that flexibility really improves the management of uncertainty.

Also, we offer various lead-time quotes, you would say: for this price I can deliver it in 2 days, for this price I can delivered in 5 days. So, you do this type of a pricing-cum-flexibility type of situation. You also can employ adaptive workforce. People who can adapt as they go, say for example, you know this is similar to people who can do different things, like they be a cashier or they could be a salesperson and so on.

Another thing is risk pooling (Refer Slide Time: 27:24). Now, this is an antithesis to inventory in some sense. So, this is a store, this is an inventory, this is a central warehouse and these are the stores.

So, let us say you have 3 stores in the city; instead of carrying inventory in each of these stores in the city, you carry a lot of inventory in the warehouse and maybe go and drop off inventory at the stores whenever you need to. This is another thing that is done very often. Especially in larger things such as- you know in the automobile industry. For example, if the stores are essentially dealerships; you do not just carry a ton of them there. Because you know it is a little expensive to keep them. So, you carry it in the warehouse and thereby manage risk.

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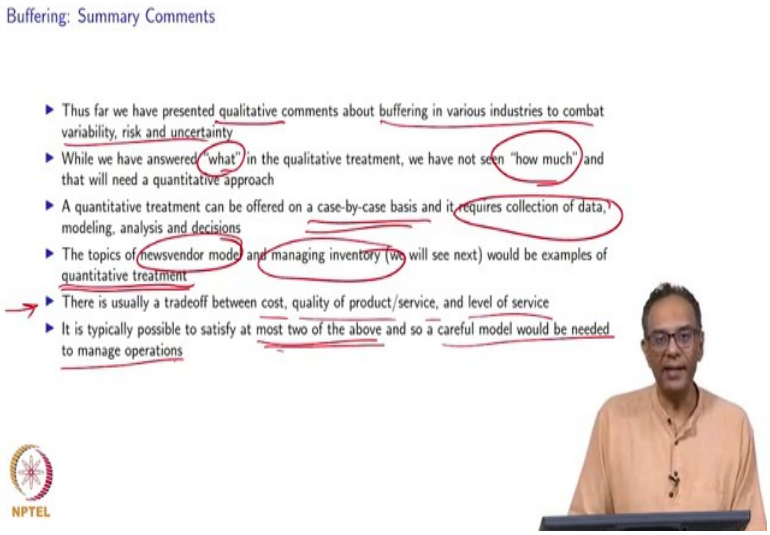

So, in summary, I do want to say a few things. We have mainly presented qualitative aspects. We have really not talked about anything quantitative, but it is good to know how companies combat variability, risk and uncertainty. This is a fairly standard technique like I said- "Factory Physics" is a wonderful book to read and learn more about this.

We have only answered the- what question, what can you do to manage uncertainty. We did not answer the question- how much? We will see how to do that in the inventory case next. But, on the other hand it is good to know what all is available. There is a lot of papers that go into deep quantitative analysis; some of these analysis require more advanced topics such as linear programming and things like that and therefore, it is a little bit beyond the scope of this course.

So, we are just keeping this to qualitative for now; also the quantitative treatment is typically done on a case-by-case basis. It requires also collection a whole bunch of data. So, what we would typically do is- study one particular situation and look at how best to analyze that situation and it could be different for them as opposed to somebody else.

Now, next is- we want to say little bit about what type of quantitative treatment. And we did see the newsvendor problem and we did manage that inventory. We did a fairly quantitative analysis. Next we will see in the next lecture: how to manage inventory?

So, we will do a little bit of the quantitative treatment; anything that is fairly straightforward, we will not get to something really tough. I should repeat what I said in topic one, which is: there is always a trade-off between cost, quality and level of service. You cannot get all three; you can get low cost, high quality, high level of service; you have to give up on one or the other especially when there is some type of constraint.

So, usually you can satisfy two of the above and to model your operations; you will have to do it in a careful way and find a good way of going about doing it in life. So, essentially, the whole idea of doing quantitative analysis is to make sure that you find a good way to trade-off between cost, quality, and level of service. So, this brings us to the end of some qualitative aspects about buffering. Next, we will look at some quantitative aspects of inventory management.

Thank you.