Logistics & Supply Chain Management

Professor Vikas Thakur

Department of Humanities & Social Sciences

Indian Institute of Technology, Kharagpur

Lecture 46 : Capacity Planning

Hello dear friends, welcome back to NPTEL online course on logistics and supply chain management. So today we are going to discuss another very important concept which is capacity planning. So usually when we talk about production operation management, we'll talk about how we can manage the capacity within the production floor so that we can ensure the optimal utilization of the resources in terms of space, in terms of raw material, in terms of manpower, in terms of machines, whatever resources we are using. so how we can ensure the maximum utilization of those resources so that the that capacity can be you know optimally utilized as per the demand for coming from the customer so under this session we'll discuss about how we can measure the capacity and when we talk about how efficiently and how much we are utilizing the available space or available resources. And we'll talk about the types of capacity planning and then planning process. And we'll see how we can evaluate different alternatives, capacity alternatives when we talk about how we can manage short-term, long-term, medium-term capacity.

And we will end this with very small case study by using break-even analysis, how we can use that break-even analysis to manage the capacity. So, a capacity planning process involves determining how much production capacity is required to meet the changing demand for the products. right so the point here is whatever we are delivering in the market in terms of product or services the demand for that product or services is not continuous right sometime it is maybe small fluctuations are only there and then kind of we can say saturated market but sometime if it is increasing then you have to increase your capacity as well your resources as well so that you can meet that increasing demand what you will do if the demand is declining right so you need to prepare for those alternatives what can be the alternatives and accordingly you need to evaluate those alternatives so point here is how we can balance the available resources to satisfy the customer demand. So, when we talk about, if you talk about project, project management.

So, if we are talking about constructing a very big building, one kind of project. let's say that the production of that building or maybe you know the construction of that building will take altogether three years right so it's not that towards the end of those three years we will try to evaluate or we will start evaluating where we are so continuously maybe

after every month we are evaluating where we are and where we were supposed to be right So when we are evaluating that situation, obviously three things are possible. First is you are moving as per the plan, which is in practical situation will not happen, rarely happen. The second outcome can be you are moving ah ahead of the planning so that means that is also not favorable condition because if you are moving ahead of the what you have planned that means you are deploying extra resources right so that is not that you if the particular work can be done by using five man power and you are saying we did that work same work use utilizing seven man power right so that is not something we are saying that it is productive or efficient right so if we are moving ahead of the project that is also something dangerous for the project manager or if we are lacking behind the project so lacking behind so many reasons can be there right if you are falling short of resources can be one reason short shortage of manpower shortage of raw material shortage of machines so that is another thing right so this is how we try to you know develop the capacity in terms of resources so that we can meet the customer demand on time. So same is the case when we are not talking about a kind of project, when we are talking about the production.

We are dealing with products where we are repetitively we are manufacturing in numbers. So production capacity, strategy planning, and project planning go hand in hand because we try to evaluate at every step what are the requirements how the requirements from the customer are changing right because now maybe we are focused towards work how we can complete that how we are generating value and we are extracting value from the resources we are converting those values into you know some meaningful product or services and then delivering another value to the end customer so maybe tomorrow we will talk about resources will be main constraint now also we are also limited by the constants right. So, these constants in terms of resources. So, limited resources how we can optimally utilize. So, that is all we will talk about the proper capacity planning.

So types of capacity planning, if you divide in terms of time horizon, so long term, short term, and medium term. Long term is obviously always the strategic decision, whether you are talking about hiring workforce, you are talking about setting up different facilities within your supply chain. Let's say now you are coming into Indian market, Walmart is setting up their own distribution channel in Indian market. So obviously they need stores storage house, they need distribution centers, they need all the logistics operations. So, all these for that they need to set up these facilities.

they need to set up the distribution hubs they need to set up the warehouses and if they are producing something of their own so then production facilities should be there so this is obviously now at one point of time you will not expand throughout the country right

so what you will be thinking lets now explore the central part of the country India right and then maybe we will explore towards the northern region towards the eastern western or whatever your planning is whatever your product you are offering right so that means step by step you will go for expansion and you have that strategy but this is long term decision because if you are thinking setting up one facility in calcutta as distribution center or warehouse maybe that warehouse you will continue for rest of maybe next 50 years or more than that and then if the demand is still increasing from the customer you will try to expand the capacity of the facility which you set up in calcutta right so that is long term decision short term how Day routine decisions you are dealing with if a certain situation arises so this is a kind of reactive strategy for how you will quickly meet that let's say you are falling short because of absenteeism rate you are falling short of manpower in one production line so then you have maybe two-three extra people on the other production line or maybe the other production line is a little slow today because there is some problem with the raw material there is some problem with the machine whatever maybe the reason So, how you can deal with this? You can ensure the other smooth supply of the other production line and so that at least one model one product you can continuously move in the market if you are struggling with the other one. So, how quickly you will react to that? So, this is how you are managing the capacity already you have resources manpower within your production plant just you are moving manpower from this may be they are packaging product A earlier now they will be packaging product B. right because we need to move products be faster in the market medium-term planning so this is again scheduling forecasting utilize gestion tracking and strategic planning let's say if we are having seasonal demand so maybe for four months six months or over the year we can track the seasonal demand and then we know Okay this is now, let's say, the summer season, and then after that, maybe the winter season will come, so right now, the demand for the winter product or maybe woollens is not that high, so we still have time we can, you know, in that way utilize keep some ready inventory stock so that whenever there will be demand during the winter season we can move that in the market right so this is some medium term tactical kind of capacity planning you can expand the capacity build up some inventory and then later on whenever there will be demand you can meet that. So, when we talk about how we can measure the facility capacity one concept is design capacity. This is in idle conditions, you can say the maximum capacity, if you will run 24 into seven, if the nature of the machine is that you can run without any stoppage, there is no halt is required, so then whatever maximum units you can produce, you can simply say this is the design capacity.

The other concept is system capacity. I will elaborate all these three with one example. system capacity so then on the way some expected variations will be there right if we will talk about machine so may be we are changing one model to other model change over will take time so when initially we are producing may be we will produce some defects

that also will not be part of production some maintenance down time is there we need to do that routine maintenance then also you need to stop or if you are talking about man power some lunch break some snacks break coffee break tea break anything that is part of that those are expected variations so your system capacity will be little lesser than your what you have designed then actual output all unexpected variations all the negatives positives will happen right sometimes maybe you will be very close to the system capacity sometimes you will be little away and reasons are obvious let's say today we got interrupted supply of raw material what you will do with the manpower you have manpower but you don't have raw material so suddenly one machine broken down what you will do right so then absenteeism rate today is very high because of bad weather condition because of some any reason because of weekend is there or many reasons can be there. So, any these kind of unexpected variations right. So, then the actual output will be little lesser.

So, if I will say the design capacity will be highest then will be followed by the system capacity will be followed by the actual output whatever you are producing. Now, let us take the example of this classroom. Now, initially when IIT Kharagpur designed this classroom might be they thought that there will be one class and obviously if I will talk about this will be one examination hall. So, they might have figured out that these many chairs we can easily set up here. So, roughly 90 students can sit here.

So, the design capacity they thought was 90. all throughout the years exams are not going on right so let us use this examination hall to deliver the regular routine lectures as well now when I am saying routine lectures we need one stage where the professors will stand and deliver we need one board we need one projector all the equipments we need to install and then when I am saying that these all instruments when you are installing will take certain space so number of chairs will reduce may be up to 75 and that stage you have prepared that will not be you cannot put chairs there obviously and then you have to maintain some space between chairs and the stage in between also you need to keep some space so this is now the effective capacity the actual output is any day you check the number of students may be 50 sometime 55 60 maximum are turning up for the classes that means still if 60 are coming 50 we are producing less that means that much capacity those many chairs are remaining unutilized those 15 chairs are unutilized So, this is happening in the rearward also when you are designing the capacity that is very high, but when you will put all the practical constraints there all the practical setup will be there. So, obviously your actual output will draw further. now we need to calculate the efficiency efficiency obviously whatever the effective capacity is not the design capacity right so obviously i cannot i can never put chairs on the stage so that should not be part that is part of design capacity but not part of effective capacity. So, efficiency we can

calculate whatever we have available, whatever we are producing the actual output divided by the effective capacity multiplied by 100 that is the percentage efficiently we are using that space.

Utilization is obviously the actual output and the design maximum capacity. So, later on you design the stage you put all those equipments required TV screen camera and all those things that is later on you added. So, this is how you can see utilization and efficiency will be you know little higher than utilization. utilization obviously will be very less compared to actual output and then you can find out effective capacity the design capacity minus allowances all this whatever furniture you need to set up not only chairs are required right you need to set the desk also so that desk space also you will be utilized. So, this is one example just you can go through the actual production was this effective capacity is this much.

Now, design capacity was we can produce 230 units per hour. What if we will run 7 days all 3 shifts that means 7 into 3 into 8. So, these many hours will be there 1 hour we are producing 230 units you multiply by 230 we should produce 38640, but how many we are actually producing? Actually we are producing this much and effective capacity is 28000. so you can simply find out utilization is 64.7% only efficiency is 89.

3% see utilization we can't do much wherever we are restricted by you know limited by that space we cannot utilize that but yes efficiency whatever available that capacity is we should try to reach somewhere 95 percent or more than that yes 100 percent cannot be there because changeovers will be there breakdowns will be there so those all things will be part of that process right now types of capacity planning first is workforce capacity planning so workforce means we are talking about the manpower see whenever we are talking about planning the resources in management we say we are using five M's as resources and those are manpower money machine material and methods or technology. These are the resources we are scheduling always. So, we are limited with these resources, we are limited with money, we are limited with machine, we are limited with the raw material, we are limited with the technology and obviously man power. obviously if 100 people are required all the time 100 will not be there some are leaving the organization permanently some are on means absenteeism rate is also there some are dealing with some other problems so these situations will be there so right number of workers and hours productivity how we are calculating if we have five people for eight hours so 40 hours we have so if one hour one person can produce this much so 40 hours how much product we should produce right this is how we are calculating so product capacity planning right number of products or resources needed to fulfill the deliverables let's say you are saying that like the example here is pet store so that means pet store

means you should get all the items related to your pet there only not only food you should get pet toys also you should get the equipment to you know maintain them you should get all the accessories required to handle your pets you should get even medicines if available so those all resources if I am saying I am automobile services provider or may be you can come and purchase the car as well right and i am providing all the financial support services all the after sale services so that means you should have all the accessories you should have insurance facilities within your facility you should have financing facility maybe the other party is there but you should have that facility right the bank has set up their office in your retail showroom but yes that should be there if you are promising that and then if you are saying after sales services are also there so whenever you are requiring the services for your vehicle you can go there and you can get the services and spare parts as well right accessories also we need so that means that one stop solution should be there for that particular industry or product you are talking about tool capacity planning so whatever machinery vehicles assembly line parts are required they should be there when and in what sequence it is required right so this will talk about in the very next session when we will talk about sequencing and scheduling right so these resources should be available resource capacity planning so here we try to maximize the capacity of the existing resources if you are having machine and that you can run 24 into 7 so if you are running only 6 days or 5 days you are not exploiting that for 24 hours you are running only in 1 shift or 2 shift that means you are not fully utilizing so that reason may be you are only operating in 8 hour shift and may be 7 days so rest of 16 hours you are not using that machine and the reason may be because that much demand is not there Demand is one problem. But yes, that 16 hours, that machine is idle.

When we will talk about the productivity of that machine, obviously I will calculate productivity that you should produce 50,000 items, but you produced only 20,000 items. Right, so that much capacity was their system capacity was there, but you produce 30,000 less now when demand the very next question comes demand is not there what will do by producing extra we can produce for other players be our competitors if they also require the same kind of material component we can use that existing machine for 16 hours and this is how most of the organizations are doing If you will talk about the moulding plants where most of the plastic parts we are producing. So, maybe one moulding plant is there which is producing the plastic products and then supplying to Philips within in house right and then there are so many other competitors of Philips, Hevels, L&T, ABB, other Usha other players are there so you are not able to utilize that machine capacity fully let us you know we can utilize the capacity and we can sell those plastic components we can manufacture for other our competitors as well. Project capacity planning already talks about how many resources are required, how many machines, and what manpower is required. Initially, we are estimating that this project should be completed in 3 years.

So, how much we have like we are using Gantt chart we are having different activities A1, A2, A3 and x axis we are having timeline and then we are saying that this A1 activity should go up to this point. A2 activity will start somewhere here, will go up to this point. B3 activity will start and will go up to this point. Now, as the project progresses, I will see up to fifth week this much part of A1 should be covered and this much part of B1 should be covered. Let us check how much we have covered.

I will highlight whichever part I have covered and I will see I am lacking this much part. right so still we are reaching we have reached here and we are lacking this much part that means we need to speeden up so what is the reason why we are lacking reason may be you are limited with the resources or you have the resources but you could not use optimally right that can be also the reason so capacity planning process here are few steps first is estimate capacity requirement what are your capacity requirements that will depend upon how much is going to be the demand you will forecast your demand obviously we have seen how you can forecast your demand you need to define the demand function whether demand is depending upon the population demand is depending upon their purchasing power their income the price of the product price of the complementary goods the quality of the product availability of the product so many factors are there but yes you have configured a demand function and you know this much per week per month six months every year I need to produce and this is moving like this the demand is moving like this so there is growth so it will go like this or it is moving like this or it is moving like it is coming down so you need to plan so that you need to estimate the capacity requirement once requirements are done evaluate the existing capacity ok so this much is the capacity required and right now we have only three machines five are required so obviously we need to go for the other two machines but if we will be having five machines the fifth machine will be utilized only thirty percent seventy percent we won't be able to utilize so what we will do with that seventy percent extra capacity identify alternatives then we need to find out different alternative let us not go for fifth machine fully we will have four machines only fifth we will that much part we can outsource or purchase from some other vendor right so once we will be sure that this fifth machine capacity will also will utilize fully then we can purchase the fifth machine as well right then so many different alternative will talk about how we can find out those alternatives conducting financial analysis also this is what I was talking about if you bought a machine and the initial cost of that machine is very high And you are utilizing only 30% part of that machine. Obviously, there is no point of purchasing that machine. So, you can see who are other players who are manufacturing those components and you can for the time being for 6 months or 1 year or so, you can define that we can purchase those components from that particular vendor. Assessment of qualitative issues of alternate, this is also very very important.

let's say right now you are experiencing little high demand in your product so what you will do you may outsource or you may yes you may outsource to some third party but your organization the employees attached with your organization may feel insecure because you are outsourcing your function to some other organization whether you are planning to outsource completely that may be the message organization culture if your organization culture is maybe you maintain the work hygiene you maintain all the quality standards and then you are producing whatever you are producing right but the other company culture is they focus only on production so if that is the scenario then the cultural difference will be there and then how the supply chain stakeholders will take so if you are you know purchasing raw material for producing that product now earlier you were producing 50,000 items now the demand is for 75,000 you will still produce 50,000 item and 25,000 item you will outsource now your vendors must be looking that for this 25,000 order they should supply the raw material but because you outsource to third party now you don't have control from where they are buying otherwise you should mention in your contract that from where we are getting the raw material you should also get the raw material from there only but yes that again depends upon how you are negotiating with that finding best long term alternative how we can balance the capacity with the requirements first alternative you increase the capacity how you can increase the capacity obviously you can have a new equipments more machines more resources this is how you can increase the capacity. right second is optimize existing capacity so existing fully you are not utilizing so how you can utilize fully so maybe if we are saying that there is stage and during lectures we we require the stage where professor can stand and deliver but during examination time that stage is not required but that is fixed stage so can we have that movable or temporary stage where the cost is not high whenever stage is required we will Take it on, and when it is not required we can remove that stage so that an extra 15 chairs can be set up right to outsource production which I talked about if we are not sure that we will utilize the total capacity we can outsource use a flexible workforce So this is also the concept that temporary you can outsource or part time worker. But if you are a very good brand, your image is you are ethically very strong. So hiring people for part time can be something go against your brand image. You cannot just hire people when required and fire them when they are not required, so that is again against your culture is not supporting rights.

But yes, then, many organizations take this decision in different ways and implement demand management strategies, so you know that anyhow you cannot increase right now the capacity so let's increase the price so rationing you can do that earlier I was buying maybe two products I'll buy only one product because now the price is very high I'll wait for some time and then price will come down again I'll go for the purchase right so that also you can do develop contingency plan some inventory you can build up you can have

some backup supplier so that those situation you can make and sometime you can come up with new technology and fully automated when you are doing that obviously the output will increase the productivity will also increase implementing the best selected alternative these all alternatives are there whatever suiting the best to your organization culture to your manpower and your stakeholders are happy with your decision you will check the feasibility will all with all those stakeholders and then you will implement you will do the cost benefit analysis as well right so then monitoring results then you will keep on monitoring the results and then somewhere you will realize ok now let us go for our own facility and then we will not outsource right that also can happen so this is what I was talking about may be your growth pattern is like this or it is declining so let us when it is declining we know that it will decline further let us introduce one new product so that we can utilize that capacity If it is cyclic demand here, we have the maximum resources so during that downtime what we can do like during summer times two more than two months' break is there in any educational institution so those big buildings all the lecture halls are vacant no one is utilizing that all the facilities it's not that that facility we are not using the equipment we are not utilizing the ac the machines the projectors and if we'll turn on after two three months some some equipments may break down because we never operated for that long period so that can happen with industries as well so how we can utilize during that time can we have some extra programs like MDPs, FDPs, training program within the campus and then people are coming temporarily staying here for 10 days, 20 days or 15 days or maybe 1 month or 2 months so that that capacity also we can utilize and we are generating the revenue no fixed investment is required only the logistics requirements are there so that we can meet and we can meet from the registration fee or whatever and if it is stable that is the perfect position anyone imagine for that So now evaluating these capacity alternative is very important and the basic tool which we can use is break-even analysis, how you can plan the capacity. And some other public opinion, your stakeholders, how they are reacting to that, we can go for that. So, this is break even analysis how we can use that break even analysis and break even analysis you know that there is one fixed cost to set up that plant there is one variable cost and if I will add the fixed cost and variable cost that will be your total cost fixed cost plus variable cost and there will be some revenue total revenue like this it will be. break even point is this point where our total revenue is exceeding the total cost that means this let's say this quantity is break even quantity right so here you can write sales you can write profit whatever you are measuring market share that you are measuring right so when your this revenue will take over your total cost that means that quantity this point this is the break even quantity so if you are producing less than this break even quantity that means if you are lying in this zone it is better you should outsource you should manage your capacity by outsourcing that product but if you are producing more than this break even quantity you should produce in house because after that you will start generating the revenue this is the profit region and this is the loss region right so this

is the main concept of your break even analysis you can see total cost already i talked about the fixed cost plus variable cost and variable cost will be how much units you are producing and variable cost per unit total revenue will be how many units we are producing and revenue per unit and this is the volume of output we are producing and we want that this output q should be always greater than your break even quantity which is QVEP and then we will get the profit right. So, this is how you can calculate the break even point because at that point we are maintaining the equilibrium.

Here your total cost is equal to total revenue. So, total revenue is this total cost is this you can equate this from this equation your quantity will be equal to break even quantity this is the break even quantity. So, this is the relation how you can find out break even quantity fixed cost divided by R minus V R revenue per unit V variable cost per unit. so this is one example you can just find quickly go through if i need to find out this is one pizza manufacturing unit so they just want to find out how many pizza they should cook so that they will be on the profit side so this is the fixed cost this is revenue and variable cost per unit it is defined here the data is given you can find out the break-even quantities 800 pizza So, minimum 800 they need to produce if they are expecting order less than that which is the case right now 700. So, that means this is not profitable investment you should outsource this.

You should outsource to some other restaurant who is already cooking the pizza and then you can channelize those 700 orders from there. So, other parameters also you can calculate from here. Another decision is to make or buy. This break-even analysis beautifully we can use, like I told you, this is your fixed cost, this is your total cost, which is your fixed cost plus variable cost, and this is your total revenue, right? Now, this is the break even quantity. so whether you should make or buy obviously if your quantity order whatever you are producing is less than this quantity means if this is loss region this is profit region if you are lying here you should outsource and if you are ahead of this point you should produce in house this is how simply you can make the decision no controversy on that if you are producing now the point comes if you are producing less than that break even quantity to whom you will outsource because that person will also be below your break even quantity no because that person may be getting orders from other competitors as well for him he can achieve that break even point quantity but because you are only producing for yourself so that order quantity is little lesser than the break even point now this break even quantity depends upon the you know the plant size also sometime what happens may be you will get break even point so early sometime may be you will get the break even point little late the reason is because this is Big size plant is small size plant, so if your plant capacity is very high obviously the break-even quantity will be very high if your plant capacity is low your break-even quantity will be

low now you have to make a trade-off between two, why because if you will set initially very low quantity low capacity of your plant what you will do if your capacity you have to make capacity double overnight the response is coming so so positive from the market what you will do with that right but the other point is if the customer will not react in the way you are thinking what you will do with the existing that big size plant So, you have to make the trade off in between.

So, this is another you can see make how if you are doing make in house. So, fixed cost for setting up that plant is this much variable cost per unit is this much and if you will buy you have to spend 150 dollar. per unit. Now, we have these many units to produce and you can see how we can find out the break even point you have fixed cost variable cost to buy and to make and this is the total your break even quantity that is 3200. Now, if you will make this in house this is the cost.

Because, this fixed assignment is required per unit you need to have 100 dollars per unit and 1000 is the requirement. Now, the one way is you can check easily because this is 2 lakh 60000 if you will buy the cost will be 1 lakh 50000. So, obviously you will go for buying that. right and also you can check this quantity is 3200 and because you are producing only 1000 that you also you can compare with the your break even quantity it is less than that you should buy that because if you will start producing so then you will be on the loss side. So, here I want to just elaborate little bit on this break even point how you can utilize this to manage the existing capacity of the plant.

Let us say this is the quantity and the same break even point I am talking about I am having plant A this is plant A. So, let us say this is the revenue and this is the total cost of the plant. So, this is obviously the break even point for the quantity for plant A. Now, if I will extend this obviously this much maximum I can produce because I am running my plant only for 12 hours. right this is maximum I can produce but I'm feeling that still the demand is increasing so what I can do I can increase my capacity I can increase my capacity by doubling the shift.

So, instead of operating for 12 hours, now I will operate in 3 shifts, all 24 hours I will operate my plant. So, if you are operating in extra shift, obviously little higher cost will be there. But yes, profit will be still there because you are having that revenue. But this is the maximum if I am producing using this and this is 24 hours maximum capacity. right now what still if still your demand is increasing so what you will do you will do some at this point you will invest into some fixed assets you will hire more machines more manpower you will maybe expand the capacity how you can expand the capacity maybe

the In the classroom, I was talking about letting us break this one wall, and we will also include the next room.

And in that way earlier we were having only 90 capacity. Now we will have 130 capacity. That also we can do. So that fixed requirement is there. If you are going for more machines, obviously fixed.

This may sometimes cover your revenue because this is total revenue line. This is total cost line. So, that depends upon the nature of the industry whether your this expanding this capacity will overcome the total revenue or will be still lower than that. If it is lower than that at this point we will start producing then your total revenue will also increase. Let us say after expanding everything this is maximum we can produce for plant A.

Now, there is no option we have explored the double shift all 24 hours 24 into 7 we are working we have expanded the maximum available space whatever was available machines manpower whatever we have done that now still the demand is increasing. So, obviously now I need to set up one more production unit plant B and then I can again may be this time the total cost will increase overcome the total revenue. Because now plant A plus plant B is there. So, again plant A and plant B capacity will increase again you can go for double shifting and all that will be there. So, this is how you can utilize this break even analysis for maintaining your existing capacity.

So, these are the references you can go for further reading. So, that is all for this session on capacity planning. Thank you very much.