Modelling and Analytics for Chain Management
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Lecture 17
Warehouse location models - II

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Welcome, now in the previous week what we learned was warehouse location decisions. We gave you the basics of warehouse location decisions and we learn the factor rating model and we mentioned that it is a very simple model, but then it is a very useful model when you are in a small business and or when your business is within not that much of a geographically spread location. Now, today we will move and then what also, we mentioned that this model this factor rating model is very helpful, when we are not having quantitative or cost data.

When it is only perception and some rating or ranking by people in the industry, when it is perception oriented then this type of a model is simple and it helps. Too much of perceptions or numbers based on perception, when it becomes very huge then the decisions sometimes are not consistent. But when it is a small one using a perception data factor rating model is helpful. And, the next model that we will learn is when you have data when you have cost data. How to decide on warehouse location that is our second issue today.

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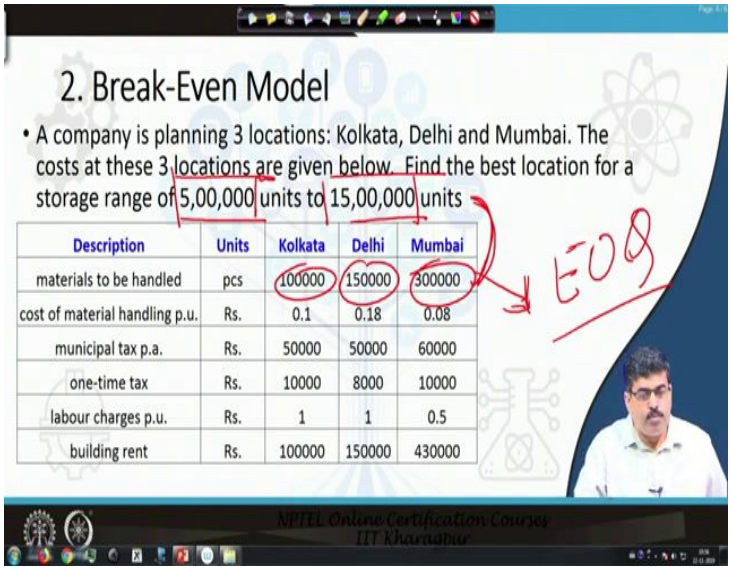

And, this is what we call as a Break-Even Model. Now, what is this? Let us is look at this information, a company is planning 3 locations Kolkata, Delhi and Mumbai. The costs at these 3 locations are given below find the best location of a storage range of 5 lakh units to 15 lakh units. So, here we are introducing something see what happens is normally I will say that I will produce 5 lakh pieces of garments but demand may change. So, tomorrow instead of 5 lakh pieces of garments, I will produce 6 lakh pieces; I will produce 7 lakh pieces.

So, what will happen will I keep on changing my warehouse, because initially I took 5 lakh square feet of space next day demand is 6 lakh. So, I will take 6 lakh square feet of space next day I will take 7 lakh square feet of space. So, that is not proper that is not as a possible. I may want to have a 10 lakh square feet of space for my warehouse, but I may not get it that may not be available. So, we also sometimes keep a range within which my output will vary. I know that my market demand is 5 lakh units and given a demand forecast. I pretty much presume that it will never surpass 15 lakh units of garments.

So, I want a warehouse which can store or within a range of 5 lakh units to 15 lakh units or to rephrase it, I want a warehouse location most specifically I want a warehouse location which is economically feasible for a range of storage of 5 lakh units to 15 lakh unit. I am repeating I want a warehouse location which is economically feasible to store a product within the range of 5 lakh to 15 lakh pieces or units. So, under this situation, how will you decide on the warehouse location?

Now, some information we already have, we have that Kolkata will handle 1 lakh pieces of units, Delhi will handle 1 lakh 50,000 pieces of units and Mumbai will handle 3 lakh pieces of units. Cost of material handling is 10 paisa or 0.1 rupee 0.18 and 0.08. Municipal Taxes, 50,000, 50,000, 60,000 onetime tax at these cities labour charges 1 rupee and building rent is again 1 lakh, 1,50,000 and 4,30,000 units. Now, there is a question. That should come into your mind. My storage range is 5 lakh units to 15 lakh units.

But, I am putting my storage range is 5 lakh units to 15 lack units, but I am putting materials to be handled as 1 lakh, 1,50,000 and 3 lakh. So, it is anyway less than 5 lakh. Why is this happening? This you will learn in another module called Economic Order Quantity or EOQ. Where we will see why this quantity becomes less. Because, all materials are not coming in at the same time number one. Number two, another reason why this is done is, see we are now doing garments business. But it might happen that I have also trading in some other units whose demand is in again the same cities where the garment has sold.

So, I will require space not only for garments, but for those units also. So, that is one reason why I might require more space in the warehouse. So, do not get confused with these two contradicting datasets.

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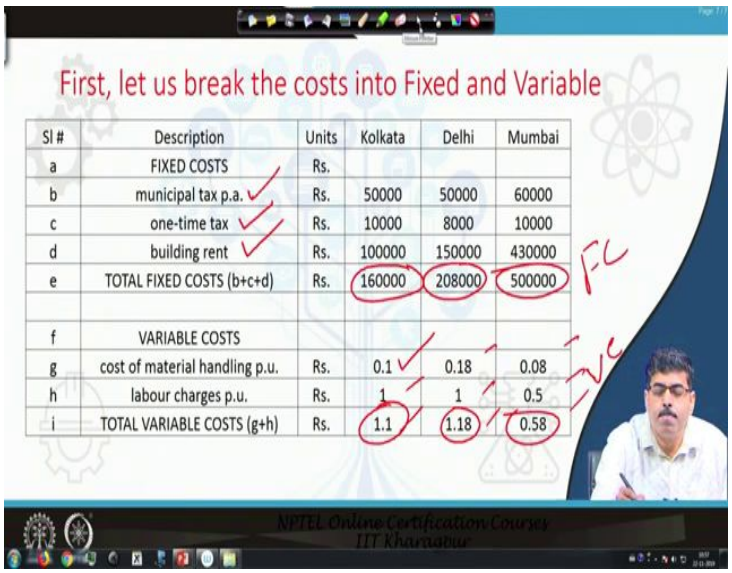

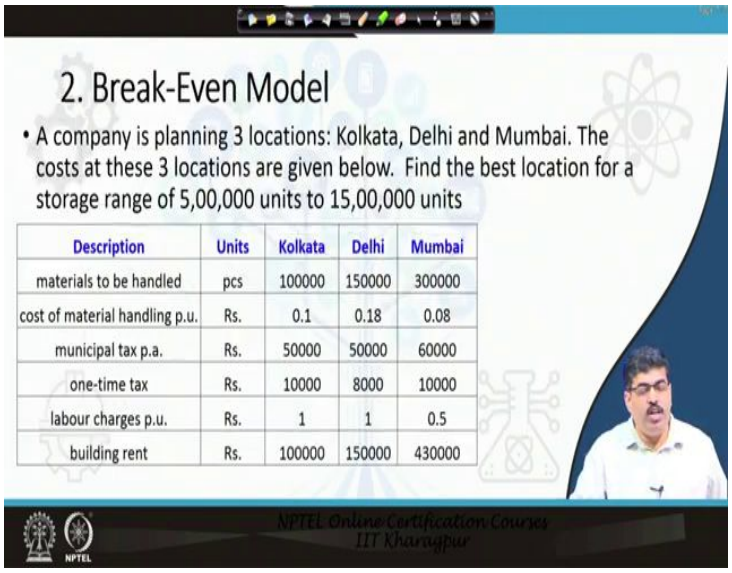

So, how will you solve the problem? Let us break the cost into feast and variable costs. First, this was my original data sets look very simple. But, now let us break it up. If you see municipal tax is a fixed cost one time taxes is again fixed costs it will not be repeated and building rent again will not be variable. So, these are my fixed costs, so total fixed cost is this, this and this. What are the variable cost material handling is this, this and this. So, this is the total, so what have we got, we have got a fixed costs total and we have got a variable cost total, what to do now?

Let us know simple like in school days with did let us now draw a graph.

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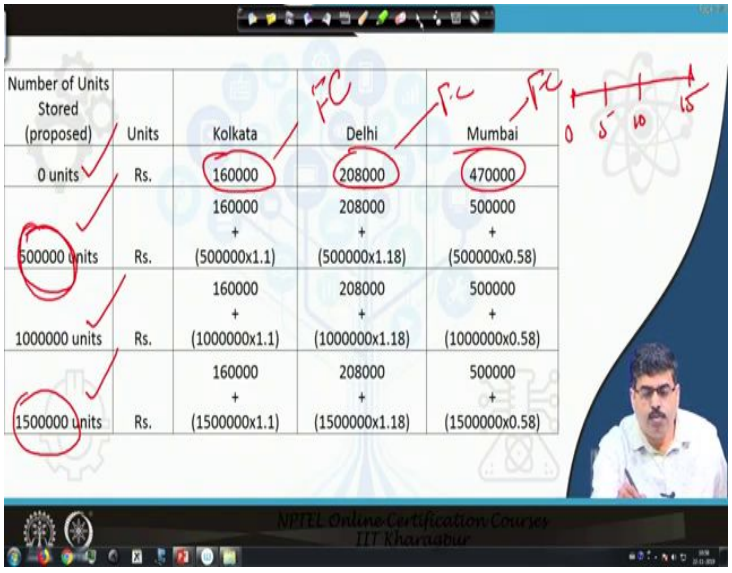

What was our problem, we wanted a range of 5 lakh units to 15 lakh units that was the issue given to us by the company. So, we have taken four quantities we do not want to store anything 0 units, we want to store 5 lakh units, we want to store 10 lakh units and we want to store 15 lakh units. So basically, we are getting a range 0, 5 lakhs 10 lakhs and 15 lakhs. So, we are getting a range. What is the cost, at 0 units Kolkata has a cost of 160, 208, 470. Why?

What is this, this is my fixed cost remember we have just calculated the fixed costs as municipal tax, one-time cost, warehouse rent these are my fixed costs. What is the variable cost? At 50,000 units 1.1 was my total variable cost, remember in the previous slide we did 1.1? Shall we go back? We may go back no problems.

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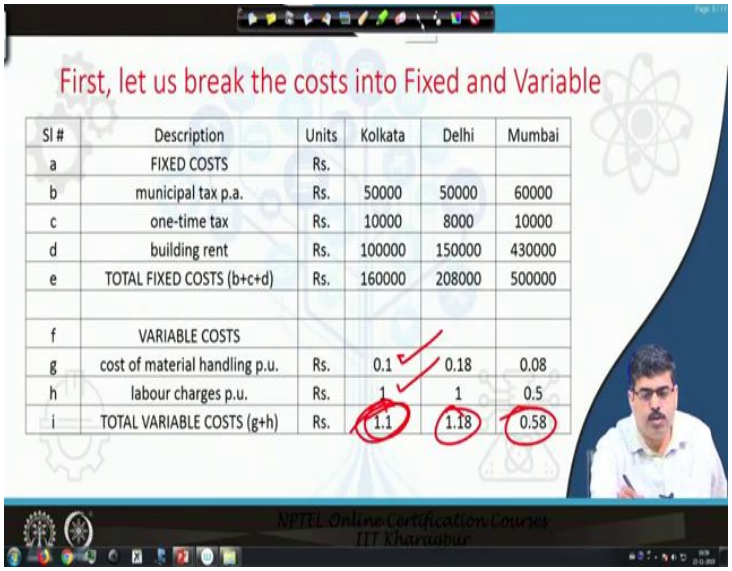

Remember, my variable cost was 1.1, 1.18 and 0.58; cost of material handling 0.1, labour charges was 1 rupee. So, total variable cost was 1.1 so, a total variable cost is 1.1

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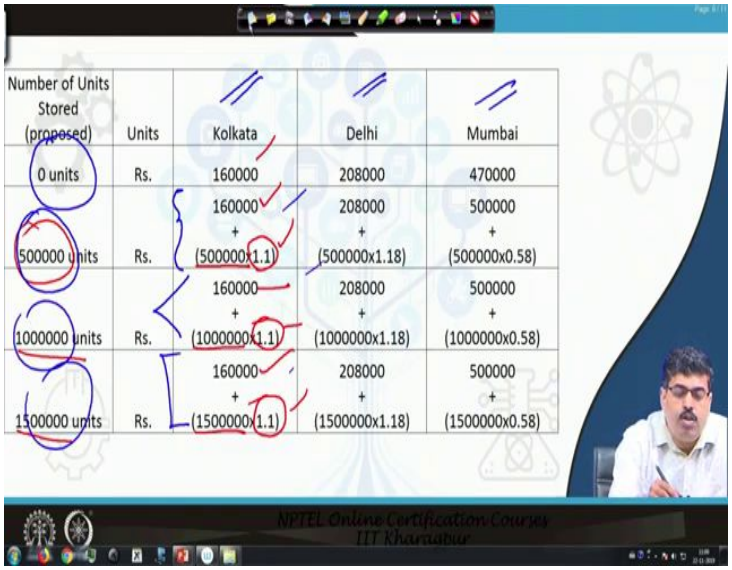

Now, so at 5 lakh units my variable cost will be 5 lakh rupees into 1.1 at 10 lakh units my variable costs will be 10 lakh rupees into 1.1 and at 15 lakh units my variable cost will be 15 lakh rupees into 1.1. What is the total cost, fixed cost plus variable cost, fixed cost plus variable cost, fixed cost plus variable cost. So, the total cost at 0 units is only the fixed cost, total cost at 50 lakh units is your fixed cost plus variable cost total cost at 10 lakh units again is fixed cost plus variable cost and total cost 50 lakh units is fixed cost plus variable cost. And this is done for Kolkata, this is done for Delhi and this done for Mumbai.

So, what have you got? We have got what have you actually now got we have got, for 0 units what is the total cost? For, 50,000 units what is the total cost? For, 1 lakh units what is? and for, 15 lakh units what is the total cost? This is what you have got.

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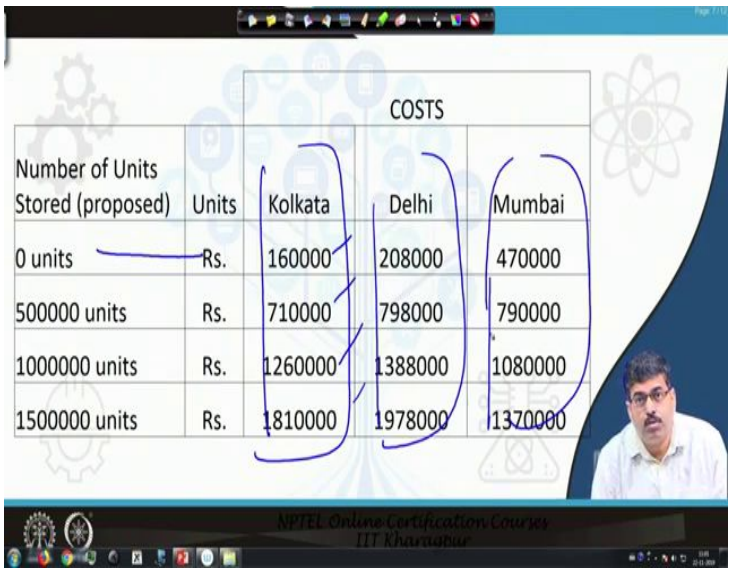

This is the summary sheet at 0 units this is my cost at Kolkata at 50,000 units this is the cost and at 1,50,000 units 15 lakh units this is the total cost at Kolkata. What do you do now with this?

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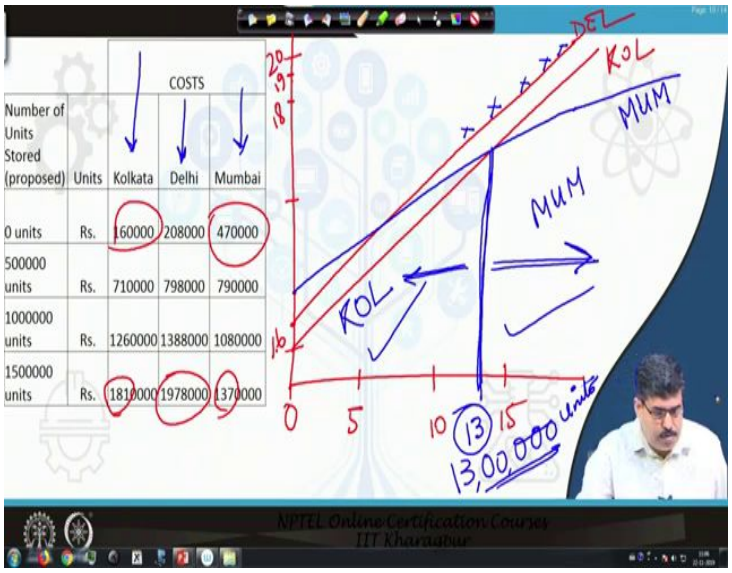

This is again the same table, we will now do something and that something is you have to draw a graph. We will have to draw a graph what are the x axis 0 units, 5 lakh units 10 lakh units and 15 lakh units. What is the minimum cost, 160 and, what is the maximum cost, 197. So, my y axis is 16 and the highest a rather 1.6 and the highest is let say 20. So, of Kolkata

will start at 1.6 and end at 181 or either 18. So, if this is 1.6? Let us keep this at 10. So, Kolkata graph will look like this, Delhi starts at 2.8 and ends at 19.7 Delhi, Mumbai starts at 4.7 and ends at 13.7, so this was 18 this was 90.

Now, Mumbai starts at 4.7 here and ends at 13.7 if this is 15 Mumbai is 16, 10 Mumbai is somewhere here, this is Mumbai. So, see now, let us look at the graph Delhi graph, Delhi is on top means Delhi's cost is the highest. So, Delhi is anyway ruled out, the issue is Delhi is anyway out. Now, issue is this blue line and Kolkata that is Mumbai in Kolkata this is the intersection point. So, roughly 13 units that means. So, 13 lakhs units, before 13 lakhs units Kolkata is cheaper after 13 lakh units Mumbai is cheaper.

Just plot the graph of all the three cities and you will see your graph looks like this. So, what is the decision? What is the implication? What is the decision for the managers? The decision for the managers is, if you have fair idea that today you are producing 5 lakh units and it will not move beyond 13 lakhs in the next 6, 7, 8, 9 years or 5 years given a projection big, given a demand forecast. So, rather have your warehouse Kolkata, if you are fair indication that the demand will increase that a galloping rate, it will increase very fast, then rather you moved to Mumbai.

Because every year you cannot change your warehouse locations you can change warehouses, but it takes time it takes a lot of infrastructure arrangement. So, it will take 8, 9, 10 years to change or is better that you can change your warehouse after 4, 5 years 7, 8, 9 years. So, if you fair idea, if you fairly convinced that your demand will not rise to 13 lakhs so easily, so quickly, than you have your warehouse in Kolkata. If you think that your demand will increase very fast, have it in Mumbai. This is the numeric way by which you can decide on by which you can choose on warehouse locations.

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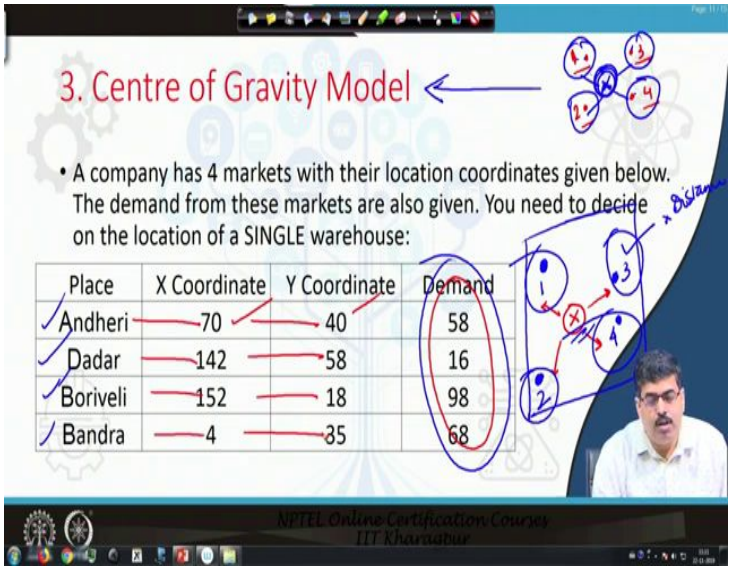

The next one that we will deal with is the centre of gravity model, centre of gravity model tells us, it does not give us any cost data, centre of gravity model only gives us demand data, centre of gravity model does not have any cost data and you will face similar problems many companies will not give you access to your actual cost. If you are a consultant, outsider whatever, they are not willing to share the actual cost with you.

They will give you some additional amount and put it on cost something like that, just to protect their business data etc. So, they will only give you the demand data. Now, this is a situation when a company has four locations, four markets, regions Andheri, Dadar, Borivali and Bandra. So, these are the four locations where the market is, not the warehouse, where the market is, where you have outlets or where you have huge customer base, your job. So, if you see this is 1, this is 2, this is 3 and this is 4. Andheri, Dadar, Borivali Bandra.

Assume that these are the four locations, what is your job? Your job is to decide on that you will have only one warehouse that will be able to serve these locations. So, now look at it look at the simplest thing possible if the demand from all these places, then look at the simple mathematics input. I, is like all of you have played this type of a game, when you were in school. These are my 4 locations. 1, 2, 3, & 4. If demand in all these locations are same, your 4 locations 1 2 3 and 4. Demands in all these locations are also same.

Then, where will you locate the warehouse? You will locate the warehouse exactly at the centre. So, that you can the cost of moving the products from all these centres. Because they

are equidistant and demand is also same the cost of moving the product from here is same for all the locations, agreed? That is why this word called centre of gravity has come, centre it is at the centre, this is centre. If these places and if the demand is equal among all these places and if these places are also equidistant from all the others, then your warehouse location is exactly at the centre. But in reality, that does not happen, these are all geographical locations.

So, we cannot have exactly equidistant location, in reality what will happen? This is what will happen. 1 & 2, 1 & 3, 3 & 4 are very close by. So, now you will have to consider and the demand will also vary from different places to different places equal demand is not possible at all the locations. So, what we now do is, we look at the demand at this place multiplied by the distance that will give you the score of this place. Similarly, that will give you the score of this place, this place, this place and based on that you find the location of this warehouse, this is a very simple one.

Let us see, what have you got? As we mentioned that demand data is shared by the company, but not any cost data. This is the situation, when you will use this model 1 warehouse. So, x coordinate and y. So, what we do instead, we look at the geographical coordinate the x coordinate and the y coordinate of these locations. We look at the geographical location coordinates of these locations.

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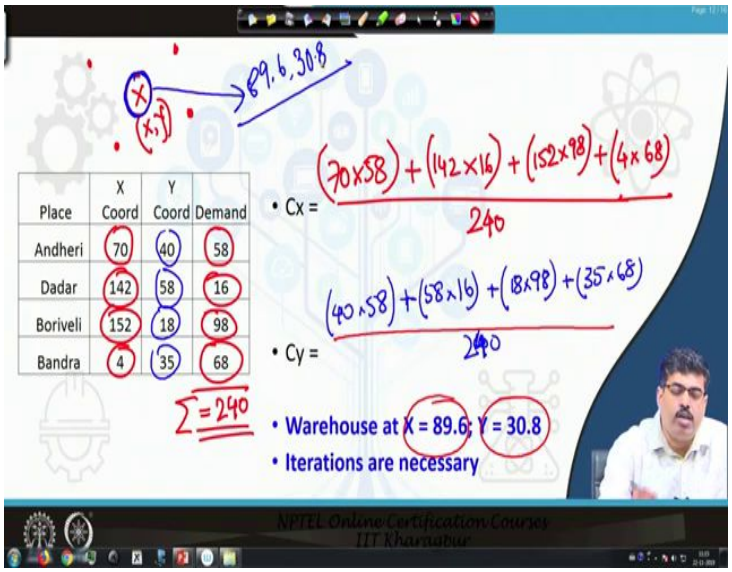

So, this was the previous problem and this was the geographical coordinates I have just copied this matrix from the previous slide. So, that it becomes easy and the demand at these

locations, are given. We want to do what, we want to find a centre, this centre also has a coordinate, we want to find out the geographical coordinate of this central warehouse, where we can locate the central warehouse, we want to have a geographical coordinate. So, x coordinate and y coordinate, what is the x coordinate, 70 into 58 plus 142 into 16 plus 152 into 98 plus 4 into 68, divided by this total.

How much is this total coming to? 150, 160 210, 24, 234 plus 6, 240 divided by this total, more specifically that is 240 this total, this demand total. What is the coordinate of y? Coordinate of y is 40 into 58, 58 into 16, 18 into 98 and 35 into 68. So, let us write it down 40 into 58, 58 into 16, 18 into 98 divided by 240. So, this is your Cy. Now, if you solve it what you will get is, X will come to 89.6 and Y will come to 30.8. So, as a first alteration your location of the central warehouse, will be at a coordinate 89.6 of X latitude and 30.8 of Y. So, this is your first location.

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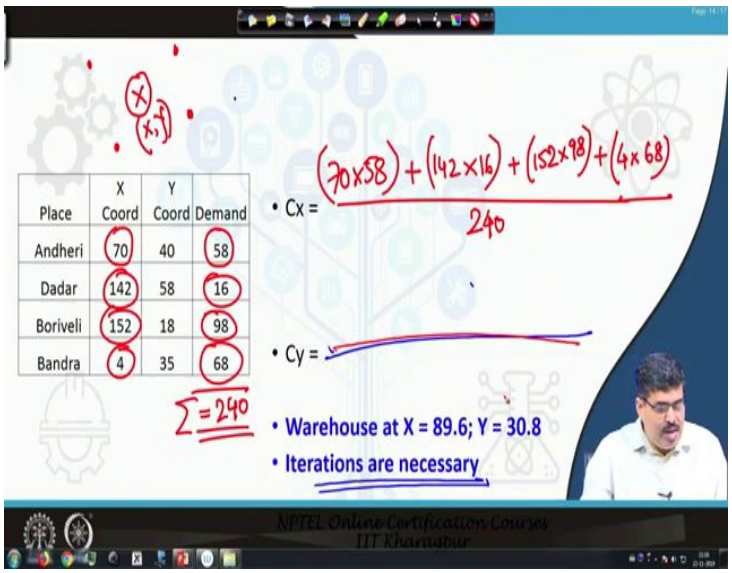

So, but then this is an alternative process, with this you move on to the next one, with this next one, till it becomes till the locations do not move to the location coordinates do not move that much this is an alternative process. We have only shown you the first alteration and it moves on. So, what did we learn till now, we learn the factor rating method, when it was a purely perception based dating, when you do not have any data, when you have only perception of the manager or people, who are knowledgeable. The second one was when you have the cost data. That is the break-even analysis.

The third one was in seen the first one factor rating did not have any data as such, third one was that is the centre of gravity is you do not have cost data, but you have demand data. So, you took on your own the geographical locations, which is available, for which you do not depend on the company you do not need to depend on the company, third one you only had demanded data with that you found out the location of warehouse, that is centre of gravity.

The next one that we will do is, the one where you will have that you want to have 2, 3 locations of warehouses, but not all at the same time, you not have the investments; you not have the money, you not have the capital. So, you want to have a warehouses first warehouse 1, then warehouse 2 to then warehouse 3. So, which one of the warehouses should come out first.

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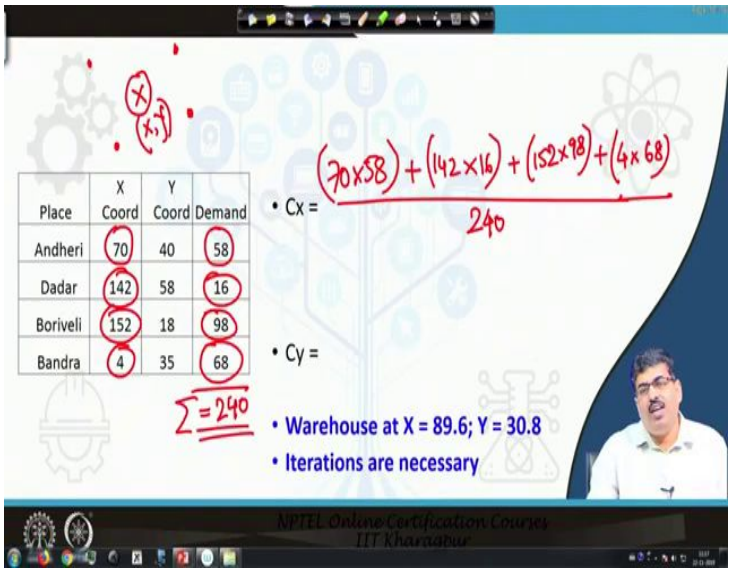

Which warehouse should come in second, which warehouse third? That we will do as the next method. That is the Ardalan heuristics. Thank you.