Retail Management
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Lecture – 20
Trading Area Analysis – Continued

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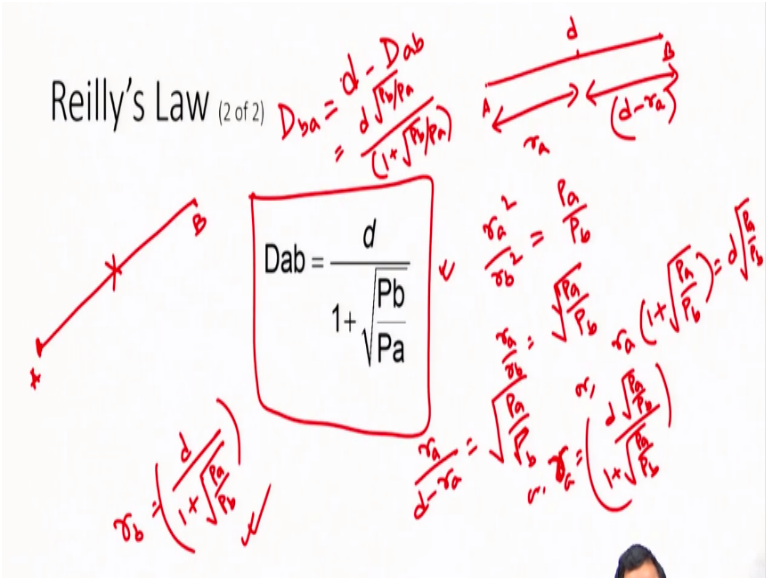

Hello everybody, welcome to NPTEL Swayam course on retail management. This is professor, Swagato Chatterjee from VGSOM, IIT Kharagpur who is taking this course for you. We are in week 4 and I am discussing about trading area analysis and in the last class we were discussing about Reilley's law and we have come up to this derivation in this last class. So, what I will do now is that I will try to solve this problem using a real problem actually.

Trading area $\propto$ Population

$$\pi r_a^2 \propto P_a$$

$$\pi r_b^2 \propto P_b$$

$$\frac{r_a^2}{r_b^2} = \frac{P_a}{P_b}$$

$$\frac{r_a}{r_b} = \sqrt{\frac{P_a}{P_b}}$$

$$\frac{r_a}{d - r_a} = \sqrt{\frac{P_a}{P_b}}$$

$$r_a + (1 + \sqrt{\frac{P_a}{P_b}}) = d\sqrt{\frac{P_a}{P_b}}$$

$$r_a = \left(\frac{d\sqrt{\frac{P_a}{P_b}}}{1 + \sqrt{\frac{P_a}{P_b}}}\right)$$

$$\text{Dab} = \frac{d}{1 + \sqrt{\frac{P_a}{P_b}}}$$

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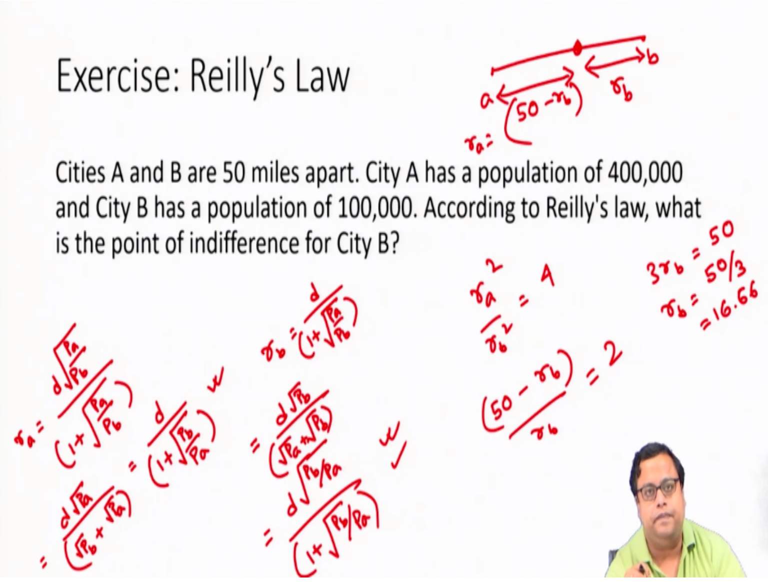

So, what I told I will write it down quickly r a is equal to d, d is the distance into P a by P b divided by 1 + root over P a by P b that is what I wrote. So, if you just multiply with root P b will be at the top and at the bottom you will also get, you see this means root over P b + root over P a, I multiplied by root P b in both numerator and denominator. And it can also be written then root P b by P a.

So, this is the line that has been written here basically, D ab means the distance from A to the indifference point towards B, So if A and B are written here in this A to B line from distance from A to the indifference point is D ab. Similarly, then what will be D ba or r b basically? The r b I wrote d divided by 1 + root over P a by P b that is what I wrote, you see here so that is what I wrote.

This can also be written as if I multiply by P b in the in the up and then then I can write it in like this way root P a + root P b and then if I divide it by P a, then I get d into P b by P a and 1 + root P b by P a. So, this is the formula. This is the second part of the formula that I have written just now, this is the formula that has been written here. So, this is D ab, so then what is D ba? D ba will be d – D ab. So, that is what will be basically d into P b by P a divided by 1 + root over P b by P a.

$$r_a = \left(\frac{d\sqrt{\frac{P_a}{P_b}}}{1+\sqrt{\frac{P_a}{P_b}}}\right) = \frac{d\sqrt{P_a}}{\sqrt{P_b}+\sqrt{P_a}} = \frac{d}{1+\sqrt{\frac{P_b}{P_a}}}$$

$$r_b = \frac{d}{1+\sqrt{\frac{P_a}{P_b}}}$$

$$\frac{r_a^2}{r_b^2} = 4$$

$$\frac{(50-r_b)}{r_b} = 2$$

$$3r_b = 50$$

$$r_b = \frac{50}{3} = 16.66$$

So, that is the same thing like whatever I wrote here at this point. So, basically you can go in any other ways, the derivation I have just shown, you can remember these or you can remember the one that I have told and just this much if you remember that is enough, you do not have to bother anything else. You can solve the rest of the thing on your own. If this much you remember, you do not have to remember the equation, this much you remember and that is enough.

Now, what is the problem? It is saying the city A and B are 50 miles apart. City A has a population of 4 lakhs and city B has a population of 1 lakh. So, if for 4 lakh 1 lakh is the population, just now I told that r a square by r b square will be 4, 4 by 1. According to Reilly's law what is the indifference point for city B, means from B to A. If A and B are 50 miles apart, this is the indifference distance for city B, you are asking me this r b basically.

So what is then this one? This is 50 – r b which is r a. So, you are saying 50 – r b square by r b square is equal to 4. Now if that is 2, then let us remove the square guys and this becomes 2. If I take a square root, this becomes 2. So, then basically three r b becomes 50, let us check the calculation. So, 2 r b + r b comes in the right side, so 3 r b = 50. So, r b = 50 by 3 that is the calculation, which is around 16.66 or something like that, that becomes your distance.

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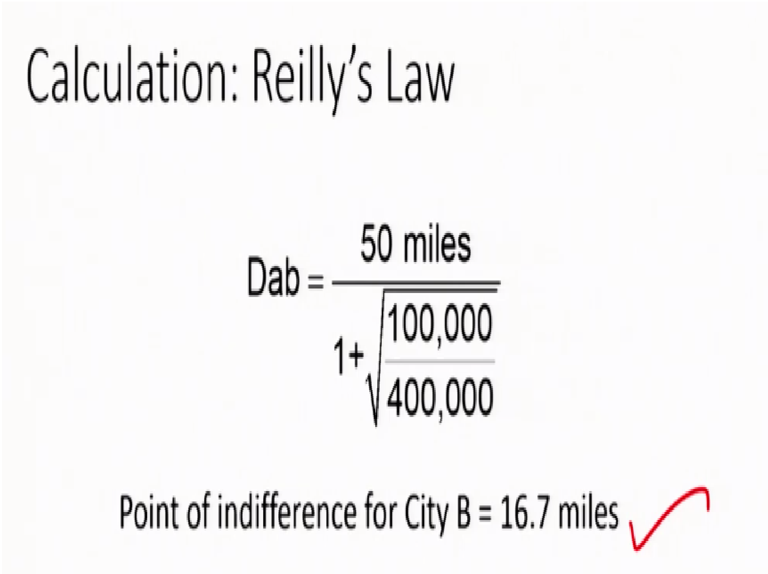

So, we calculated that 16.7 miles and that is the distance from city B till the indifference point.

$$\text{Dab}=\frac{50\,\textit{miles}}{1+\sqrt{\dfrac{100{,}000}{400{,}000}}}=16.7\,\textit{miles}$$

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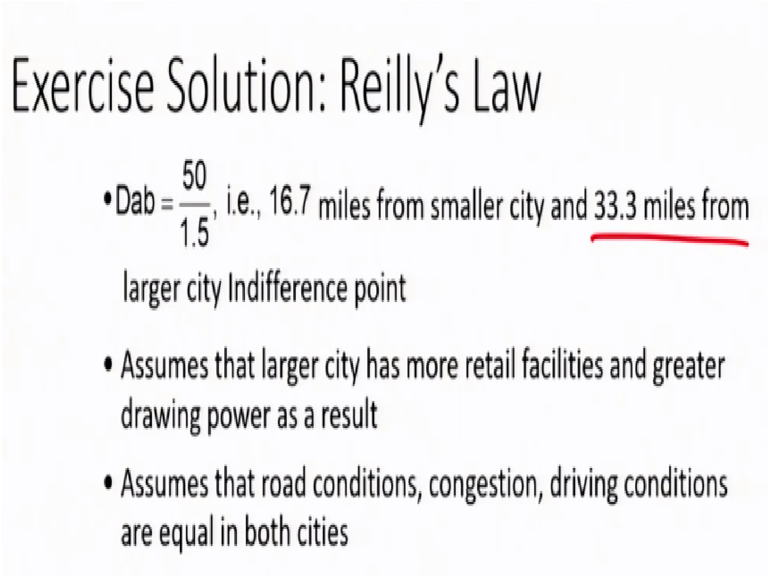

Then what is the distance on city A till the indifference point? It is 50 – 16.67 which comes around 33.3 miles. What are the assumptions here? The assumptions are that the large city has more retail facilities and greater drawing power as a result because the population is high that means the drawing power of a retail store will be also high because it will be able to catch up more business from a trading area.

It also assumes that the road condition, congestion, driving conditions are equal. So, all other factors other than population, which can impact people coming to your store, all these things will be absolutely same in these two cities, which is a very hard assumption, which is a very strong assumption which might not be true but Reilly's law, rely on this assumption. Reilly's law also relies on this assumption that there is no competition as of now.

There are only two retail stores, one in city A and one in city B. But within a city if there are multiple retail stores are there, how consumers will be choosing whether to go to retail store 1 or retail store 2 or retail store 3, Reilly's law does not, it is a gravitational based law, but that does not consider that. Now, who considers that then, so what are the limitations?

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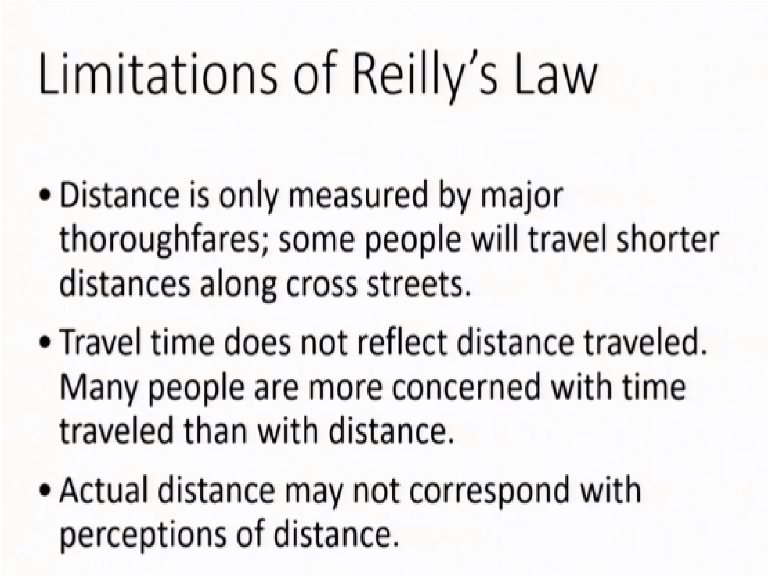

Distance is only measured by major thoroughfares; some people will travel shorter distance across cross streets. So, you are only measuring the highway, you are not measuring that whether there is shortcuts available that is number one. Travel time does not reflect distance travelled, many people are more concerned with the time travelled than the distance. Let us say I have a car, if I have a car then I will be less concerned on the distance because the marginal effort or marginal cost to drive 5 kilometres more is not very much.

But if it is a congested city or if it takes time for me to go to that place because of road unavailability then that is a pain. So, people are not more concerned about the time spent on driving rather than actually the distance. So, that road condition, congestion condition which is not considered is a very important factor actually, so somebody has to think about that. And actual distance may not correspond in with the perceptions of distance.

So, distance perception in consumers mind also come into the picture. If the congestion is low, higher distance might also be perceived as lower distance because the time taken to reach that place will be lower. So, actual distance may not correspond in the perceptions of distance which has to be thought about.

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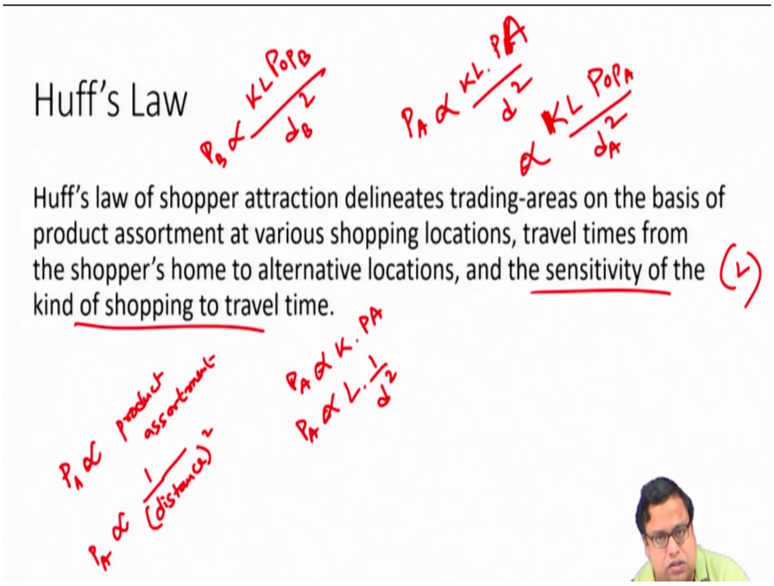

Now, next we are talking about Huff's law. Huff's law is another gravitational law where it is talking about the shopper attraction. So within a trading area, the trading area is fixed, within the trading area I am talking about which particular store will basically attract how many customers, so what will be the market share of our particular retail store? So let us say 3 retail stores are there, every retail store caters to a certain population. They have decided that this is my trading area, this is my trading area and blah blah blah.

Now I am a person in between, I have to decide whether to go to retail store 1 or retail store 2 or retail store 3 depending on their attraction and depending on the distance. So attraction part, I am saying that attraction part is proportional to the area that it serves because if it serves larger area, it will keep lots of different kinds of assortment. And if it creates lots of different kinds of assortment, the attraction of this retail store will be higher. However, the distance is something that I do not like.

So, the distance will be something that will have a negative impact on that, even here we are not thinking about congestion and etc. So Huff's law of shopper attraction delineates trading areas on the basis product assortment at various shopping locations and the degree of product assortment available is proportional to the population of that location, travel times on the shopper's home to alternative locations and the sensitivity of kind of shopping to travel time. So, these are the three factors that they consider.

For example what I am trying to say here that if your probability to shop in a particular store A will be proportional to the product assortment and it will be inversely proportional to the let us say distance and we say that distances square. Why distances square? Because the moment the more is the distance because of the travel time and because of the possible congestion, the time taken will not be linear, the time taken will be nonlinearly increased.

So that is what distance square is the pain that I am getting. So, these two, the travel times for the shopper's home to alternative locations which you come and sensitivity to the shopping. Now, if this is the case, if I take on to those P A and P B sensitivity will come in terms of the parameter. So, P A will be let us say K into product assortment and probability of A will be L into 1 by distances square, this L is the sensitivity.

Now L will go away and I will show you why. The reasoning for is so then what will be P A? The P A will be basically in the end of the day K L, K and L are two parameters into product assortment availability by distances square. And product assortment availability is basically I am saying that is proportional to the population of the trading area. If one particular store has higher population in the training area, then it will keep more number of assortments.

So that will be basically K L into population at A by distances square, it will be basically proportional to this, something like that. Now, if that is the case, then P B will also be similar, K L into population at B by distance of B square for a particular person and so on. Now, if they are proportional to this and if I have 3 three stores, then how to calculate?

$$P_A \propto PA$$

$$PA \propto \frac{1}{(distance)^2}$$

$$P_A \propto kPA$$

$$P_A \propto L.\frac{1}{d^2}$$

$$P_A \propto kL.\frac{PA}{d^2}$$

$$P_A \propto kL.\frac{P_0 P_A}{d_A^2}$$

$$P_B \propto kL.\frac{P_0 P_B}{d_B^2}$$

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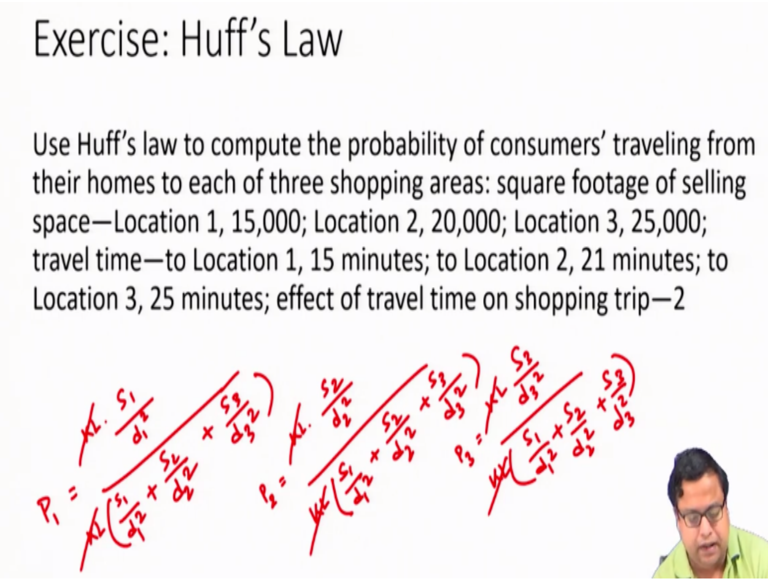

If I have 3 stores, then the probability to go to store 1 will be basically you just say K L into population 1 population 1 not square, population 1 divided by distance 1 square. Probability of 2 will be K L population of 2 divided by distance of 2 square and P 3 will be K L population of 3 that will be in the numerator by distance of 3 square, then what will be the in the denominator. The denominator will be the summation of this numerator.

So, basically here it will be K L population 1 distance 1 square + population 2 distance 2 square because these are the three companies, three retail stores which are competing square. Similarly, here we will be doing the same thing K L population 1 distance 1 square population 2 distance 2 square and population 3 distance 3 square. Same exactly thing here as well, population 2 to distance 2 square and population 3 distance 3 square.

So, exactly same thing. So, denominators are same in all these three cases, but the numerators are different and they are basically proportional to the population and inversely proportional to the distance square. It is almost like what we do in logistic regression if you know, so utility at the top divided by the utility of different options at the bottom. The K L will cancel out and that is why the risk is basically, so that is why I told that this will ultimately not matter.

This L will ultimately not matter that is why I told because this will cancel out and this will ultimately be analysis of only the population and distance. Based on that, measure what will be my market share or how many people will come to me. So, it is not always on the location, trading area's attractiveness, is also dependent on how distant your location or the trading area is from a particular person. Now, let us say this is the problem that has been given to me.

Use Huff's law to compute the probability of consumers travelling time from their homes to each of these shopping areas. The square footage of selling space, so, here they have taken assortment, not proportional to population. They have taken assortment to be to be proportional to the shopping space available, very well, so if that is the case, then I will remove that. So, instead of population here in this problem it has taking the space available.

So, I will just remove all the population things here. So, it is saying that the bigger the store is the size, the bigger the store is the more will be that attraction, makes sense as well because the bigger the store is the better will be the assortment, the more will be the attraction. So, this is S 1, S 2, S 3 which is the shopping space, S 1, S 2, S 3 and S 1, S 2, S 3 and this is basically S 2 and S 3, fair enough.

So, if the location 1 has 15,000 square feet of area, location 2 has 20,000 square feet of area, location 3 has 25% total square feet of area. The travel time is 15 minutes, 21 minutes and 25 minutes. Then what will be the effect of travel time on a shopping trip 2, means how basically people will choose which store to go.

$$P_1 \propto \frac{kL.\frac{P_0P_1}{d_1^2}}{kL.(\frac{P_0P_1}{d_1^2}+\frac{P_0P_2}{d_2^2}+\frac{P_0P_3}{d_3^2})} = \frac{\frac{P_0P_1}{d_1^2}}{(\frac{P_0P_1}{d_1^2}+\frac{P_0P_2}{d_2^2}+\frac{P_0P_3}{d_3^2})}$$

$$P_2 \propto \frac{kL.\frac{P_0P_2}{d_2^2}}{kL.(\frac{P_0P_1}{d_1^2}+\frac{P_0P_2}{d_2^2}+\frac{P_0P_3}{d_3^2})} = \frac{\frac{P_0P_2}{d_2^2}}{(\frac{P_0P_1}{d_1^2}+\frac{P_0P_2}{d_2^2}+\frac{P_0P_3}{d_3^2})}$$

$$P_3 \propto \frac{kL.\frac{P_0P_3}{d_3^2}}{kL.(\frac{P_0P_1}{d_1^2}+\frac{P_0P_2}{d_2^2}+\frac{P_0P_3}{d_3^2})} = \frac{\frac{P_0P_3}{d_3^2}}{(\frac{P_0P_1}{d_1^2}+\frac{P_0P_2}{d_2^2}+\frac{P_0P_3}{d_3^2})}$$

$$P_1 \propto \frac{kL.\frac{S_1}{d_1^2}}{kL.(\frac{S_1}{d_1^2}+\frac{S_2}{d_2^2}+\frac{S_3}{d_3^2})} = \frac{\frac{S_1}{d_1^2}}{(\frac{S_1}{d_1^2}+\frac{S_2}{d_2^2}+\frac{S_3}{d_3^2})}$$

$$P_2 \propto \frac{kL.\frac{S_2}{d_2^2}}{kL.(\frac{S_1}{d_1^2}+\frac{S_2}{d_2^2}+\frac{S_3}{d_3^2})} = \frac{\frac{S_2}{d_2^2}}{(\frac{S_1}{d_1^2}+\frac{S_2}{d_2^2}+\frac{S_3}{d_3^2})}$$

$$P_3 \propto \frac{kL.\frac{S_3}{d_3^2}}{kL.(\frac{S_1}{d_1^2}+\frac{S_2}{d_2^2}+\frac{S_3}{d_3^2})} = \frac{\frac{S_3}{d_3^2}}{(\frac{S_1}{d_1^2}+\frac{S_2}{d_2^2}+\frac{S_3}{d_3^2})}$$

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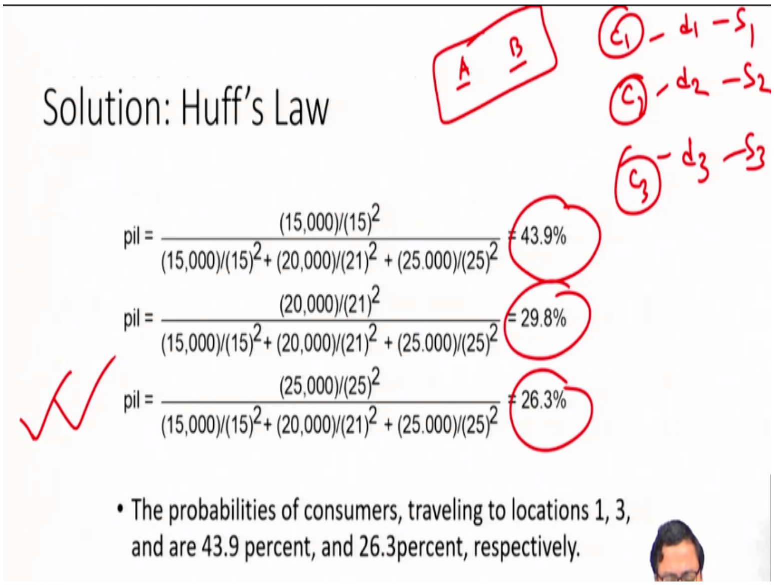

So, based on Huff's law we have just calculated just now based on whatever equation I wrote and what are the probabilities and these are the probabilities. So 1 and 2 and 3 this is 43.9, 29.8 and 26.3 is the probability of going to a particular store based on the calculation we can find out. So, if this is the case then what to do with this particular area. Now if I can by chance increase my shopping space, location I cannot change.

But if I change my shopping space, how much more customers will I be able to bring in I can take this decision or if I have not decided on the location yet, now I am just deciding that whether I will go for this location and that location, I have two locational choice at me, let us say I have two competitors A and B who are already there and I have three location choices C 1, C 2, and C 3; each will have certain distance and each will have certain space.

Now I can know which of these will give me higher market share using this calculation where A and B are my already existing competitors, these things will not change. So, their distance from the city centre will not change or their distance from an average consumer will not change, but my distance from average consumer and my space availability will change depending on these 3 choices and I can choose one of them.

So, these are mathematical ways of doing this thing. But you see that in these gravitational models also we are not considering many other factors, many other important variables we are not factoring in. So that is why a multicriteria decision making kind of problems comes up. So, if you have studied multicriteria decision making in your MBA course, you can even study them or otherwise I will share certain material along with this thing.

Where multicriteria decision making problems which are basically very important supply chain problems or vendor I would say operations management problems are solved using this kind of. S there are various decisions we take where multiple criteria is involved like vendor selection problems. Vendors are decided based on the quality of the vendor, the reliability of the vendor, the money price that they are charging, the travel, the services that they were promising.

Many other things will impact how to choose a vendor and you give weightings to those factors, then you actually analyze based on those factors multiple vendors, and you try to find out which factor is more important, which factor is less important and based on certain calculations, certain matrix algebra, you try to find out that which vendor you will go for. And there are various methods of doing these. There is AHP, TOPSIS, various other fuzzy, fuzzy TOPSIS, other fuzzy methods. So, various methods under this multicriteria decision making or MCDM.

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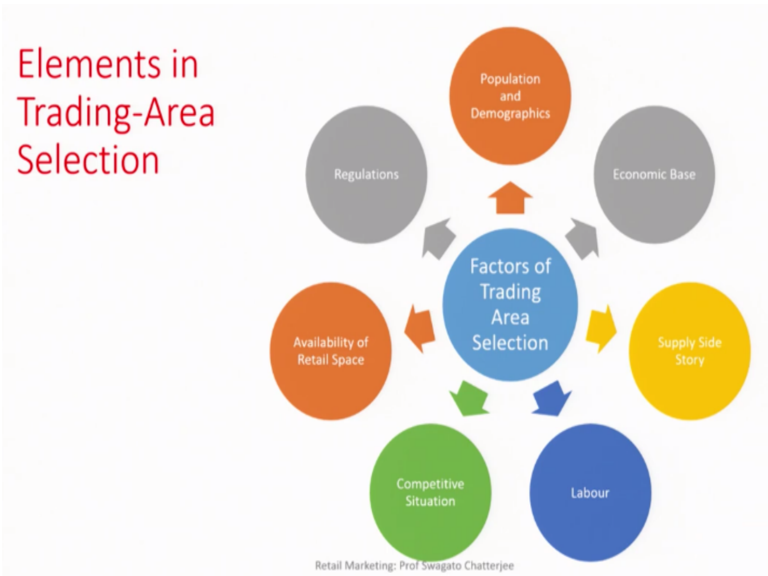

Now, I will only talk about the criteria that are important in the context of trading area selection. The criteria that are important are the population and demographics, the economic base, the supply side story, the regulations, the rules, laws of regulations, the space availability, the competitive situation of a particular store and the labour. So, these are some of the most important factors under the trading area selection which you have to also consider when you decide about the exact area of this particular location.

So, in the coming video, we will discuss in detail about these elements of trading area lecture, why each of these factors are important and what are the various factors under the broad umbrella of let us say population or economics or supply side you will have to look at when you are deciding the trading area analysis. So, please go and try these gravitational models in some of the problems and those will also be posted in your assignments or the quiz that is coming up. So, please try to solve before that and I will see you in the next video. Thank you very much. See you in the next video.