Urban Transportation Systems Planning
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Lecture - 24
Furness Method

Welcome to module D lecture 4. In this lecture, we shall talk about another growth factor based method, which is called a Furness method. And also we shall discuss general limitations regarding application of growth factor based methods.

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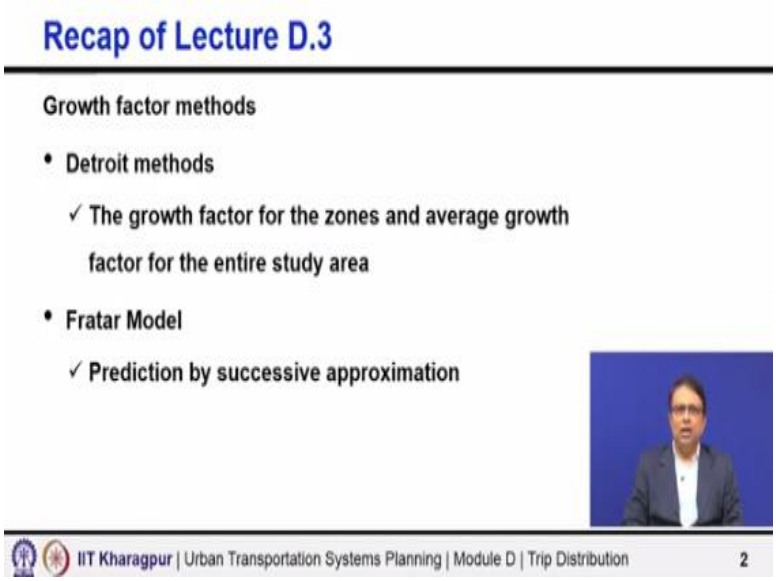

In this lecture 3, we discuss two specific methods, which are also growth factor methods they are called Detroit methods and Fratar models. In each case, we discussed how these methods can be applied and we took example problems to demonstrate the application of these methods for getting the future or horizon year design year O-D metrics to match the row total and the column totals.

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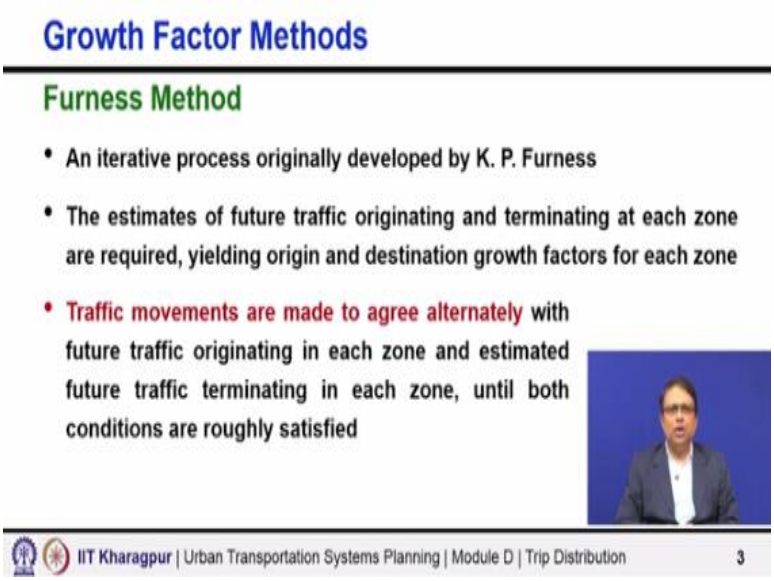

In this lecture we will discuss the Furness method which is again an iterative process and what we do here the estimates of future traffic originating and terminating at each zone are required, yielding origin and destination growth factors for each zone. So, what we do suppose we take the matrix, now the column total has to match with the future column total and the row totals match with the future row totals.

So, we take a column and then see what is the present total and then what is our target total, then target total by present total that is the factors, that is the destination in growth factor and we multiply all the cells in that column with that growth factor. Similarly we do it for each destination zone. So, if there are n destination zones, then every column we find out the growth factor and then map or multiply each cell in that column with that growth factor value then we take the next column.

Then we take the next column like that all columns in that matrix, we apply the growth factor. Now, obviously what will happen? Because of this the column totals will match perfectly. But obviously, the row total will not match. But the final matrix what we should get we expect the row totals as well as the column totals to match reasonably. So, what do we do? We go to the next iteration and in that iteration whatever we did for each column, will now do the same treatment for each row.

So, we take a row, we now see what is the row total we are getting and what is our target row total for each zone, then calculate the growth factor and then multiply each cell of that row with that particular growth factor. So, what will happen? Now the row total will be exactly, you know for that zone will exactly match with the target row total. We do the same thing for each row, so again now all the production totals are at the origin ends, the totals are will match.

But in that process the column total will now get distorted because we have adjusted the row totals. So, again, we will come back and will now again adjust the column totals as we did in iteration 1, then again we will go and adjust the row totals as we did in iteration two and this process will continue. How long will it continue? Again it depends on what is your acceptable error level.

So, you said that acceptable level and maybe you can say something that when the growth factor, calculated growth factor is less than plus minus say 5%, that means or 2% whatever you would like to set. So, accordingly you can set a value that may be 1.02 to 0.98 or 1.01 to 0.99, that is the range which is acceptable, accordingly the number of iterations will happen till you get your expected or targeted accuracy.

So, that is what I said here, look at the slide again, the traffic movements are made to agree alternatively with future traffic operating in each zone and estimated future traffic terminating in each zone until both conditions are roughly satisfied.

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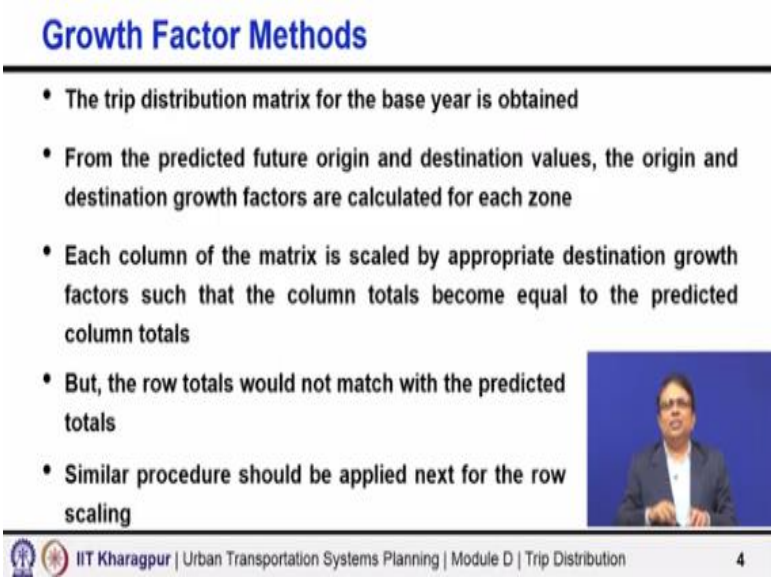

So, that is what it is, the remaining things that I said are explained here, so the trip distribution matrix for the base year is obtained, then from the predicted future origin and destination value the origin and destination growth factors are calculated for each zone as I explained earlier. Then for each column of the matrix is scaled by appropriate destination growth factors such that the column totals become equal to the predicted column total, so the column will match perfectly.

But the row totals would not match with the predicted totals as usual. So, therefore a similar process should be applied next to the row scaling and this process will continue. So, match the column totals, then match the row totals, match again the column totals, match again the row totals like that, we will continue in an iterative manner. Till we get the required accuracy or expected accuracy.

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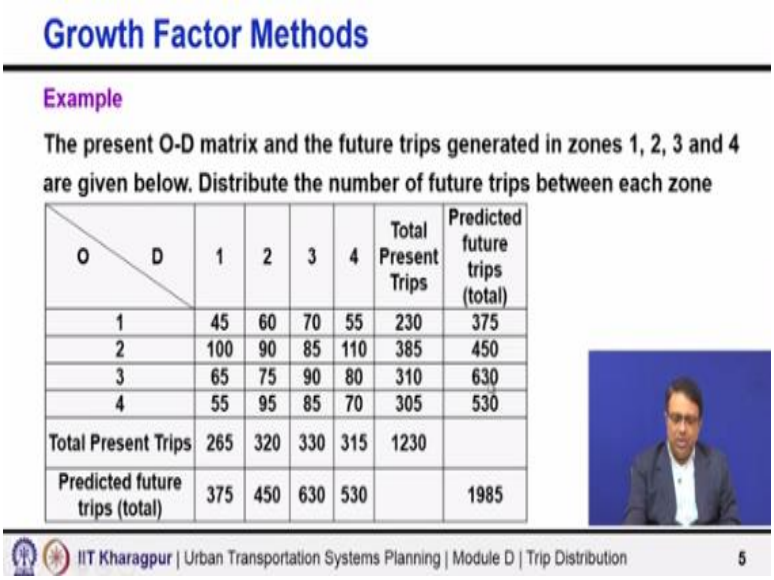

Let us take an example to explain this more clearly. This is the given OD matrix in the base year, you can see the cells 45, 60, 70, 55 and the total present row total is 230 for zone 1 or origin zone 1, then origin zone 2 100, 90, 85 and 10, so total row total is 385. Next one is 310 the zone 4, original zone row total is 305 and the total we have 1230 trips are presently distributed now. Interestingly in this example problem, t ij is not equal to t ji.

So, you can see 1 2 is 60 but 2 1 is 100, 1 3 is 70 3 1 is 65. So, it is not a matrix where the t ij equals t ji. And we know what will be our future productions and attractions of each zone that are given. So, there these values are you know, 375, 450, 630 and 530. In this example there, you know, the target totals are given the same quite possible and we need actually one 1985 trip to be distributed in the future.

So, we need to update this given matrix in such a manner that the total trips become 1985 and the row totals and column totals become 375, 450, 630 and 530 for zone 1, 2, 3 and 4 respectively. So, that is what we need to do.

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Growth Factor Methods

Solution

O \ D	1	2	3	4	Total Present Trips	Predicted future trips (total)	Origin growth factors
1	45	60	70	55	230	375	1.63
2	100	90	85	110	385	450	1.17
3	65	75	90	80	310	630	2.03
4	55	95	85	70	305	530	1.74
Total Present Trips	265	320	330	315	1230		
Predicted future trips (total)	375	450	630	530		1985	
Destination growth factors	1.42	1.41	1.91	1.68			

Column Scaling

$T_{11} = 45 \times 1.42 = 64$

$T_{21} = 100 \times 1.42 = 142$

$T_{31} = 65 \times 1.42 = 92$

$T_{41} = 55 \times 1.42 = 78$

So, what we do first, first we calculate what is the present column total for column 1? 265. What is the target total? 375. So, then what is the growth factor? 375 divided by 265. So, you get the factor as 1.42. Now each cell in this column I will multiply it by 1.42, so 45 into 1.42, 100 into 1.42, 65 into 1.42, 55 into 1.42. Similarly for column 2 the present one total is 320, the predicted total is 450 and we calculate a value of growth factor as 1.41, so each cell in this column 16 to 1.41, 19 to 1.41, 75 into 1.41 and 95 into 1.41 like that we will do.

So, what will happen in that case the column totals for each zone 1 2 3 and 4 will exactly match with the target column total of zone 1 2 3 and 4.

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Growth Factor Methods

Matrix after column scaling

O \ D	1	2	3	4	Total Trips	Predicted trips (total)	New Origin growth factors
1	64	84	134	93	374	375	1.00
2	142	127	162	185	615	450	0.73
3	92	105	172	135	504	630	1.25
4	78	134	162	118	491	530	1.08
Total	375	450	630	530	1985		
Predicted total	375	450	630	530		1985	

Row Scaling

$T_{21} = 142 \times 0.73 = 103$

$T_{22} = 127 \times 0.73 = 93$

$T_{23} = 162 \times 0.73 = 119$

$T_{24} = 185 \times 0.73 = 135$

Let us see that we have done it, so exactly now my column totals are matching very nicely, but then the row totals are they matching? No. In the first case yes, somewhat instead of 374 and 375 there is a close match incidentally, but look at zone 2, 615 and you know 450, 504, 630. So, they did not match, they did not match. So, what will we do now? Now we will go for the row level operation as I explained, so what will I do?

Let us calculate the growth factor 375 divided by 374, so we have say 1, then 450 divided by 615, so 0.73, 630 divided by 504, 1.25, 530 divided by 491, 1.08. Now what we will do, first one is 1, so each cell will be multiplied by 1, each cell in row 1. Each cell in row 2 will be multiplied by 0.73, each cell in row 3 will be multiplied by 1.25, each cell in row 4 or zone 4 will be multiplied by 1 factor 1.08, so then what will happen. We expect them the row totals to match perfectly.

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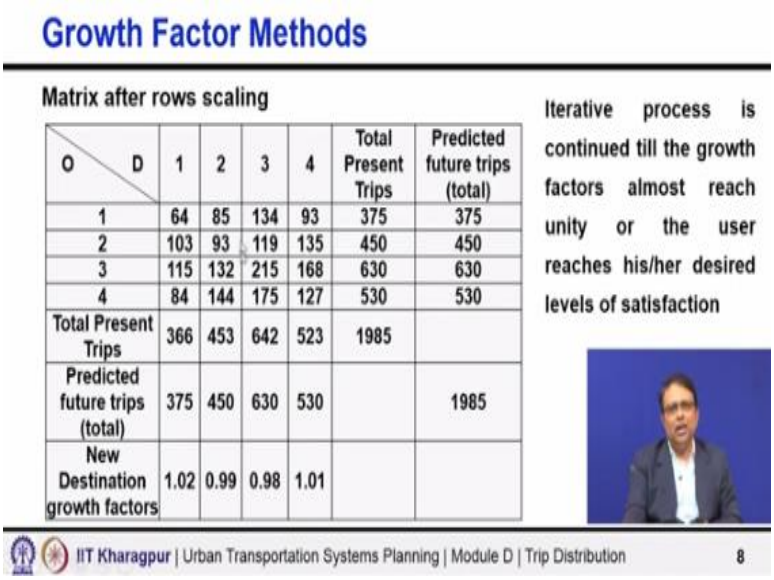

Let us see that is what has happened now. You can see the row totals are giving you a very nice and perfect match. But then what is happening? Let us look at the column total, the column total which was all adjusted very nicely, now they got someone distorted. So, the column totals are not matching as the row totals are matching now, not to that level. So, what we do is we repeat this whole procedure again, we calculate the growth factor for each column.

And multiply its cell of that column with the respective growth factors, then again the column total will match but then the row total will get distorted, so again we shall come back at just the row total like that, we shall continue.

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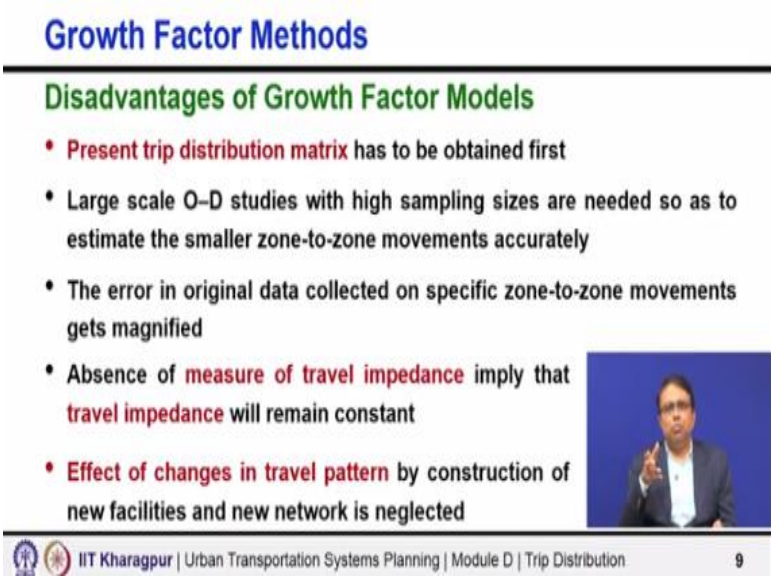

And how long we shall continue? Till we get it is a reasonable match as per our expected accuracy. Now with this we have more or less discussed all the models which we wanted to discuss in this course under growth factor methods. So, uniform factor, average factor then you know, Furness method, Fratar model and Detroit model, so many things we actually have different methods we have discussed.

Now, what are the general disadvantages of growth factor models? In some cases we have already discussed those when we were talking about specific models but it is important, so I would like to you know discuss this once again that what are the general disadvantages of using growth factor based models or methods? Number 1, present trip distribution matrix has to be obtained first. Every case we need to have these t ij. That means the present distribution matrix must be known.

Because what all we are doing we are applying a growth factor on the present t ij which I always referred here as t ij to get the future or design here t ij value which again I referred to here as T ij. So, we must have this small t ij otherwise, we cannot apply. Somebody has to give you the

present trip distribution matrix. Second, large scale O-D studies with high sampling sizes are needed so as to estimate the smaller zone to zone movements accurately.

Somebody needs to give you, therefore you will get in the field you have to measure, so you need large scale O-D studies. To capture all the movement required, you know accuracy and as for to get a proper sample. The error in original data collected on specific zone to zone movements gets magnified. Because it is again logical for all methods that are happening we are applying a multiplier and the multiplier is normally more than 1.

So, because there is a growth in different zones, maybe some factors may be much higher, some factors may be somewhat lower but all zones are generally growing in all practical sense every zone will grow, maybe less growth may be more growth in normal circumstances. So, whatever is the error in the original data collection on specific zone to zone movements, those errors are getting magnified because you are using a multiplier.

Absence of measure of travel impedance implied that travel impedance will remain constant. This is a very, very fundamental assumption, we know that the trip distribution depends and highly gets influenced by the characteristics of the transportation system, so that transportation systems changes significantly either it improves or deteriorates, both directions. There will be an impact on the trip distribution.

But we are not bringing the transportation system consideration in any of these methods or any of these models growth factor based models are overall growth factor methods. That means only thing that can support this is that, there is no significant change in the transportation network which again may be not a very unrealistic assumption, because you see that every day in a city you take a large scale city, everyday road network does not change, every big infrastructure project does not happen.

So, it may be that we had a transportation study, we already did a transportation study and we have this base year matrix. And maybe in the last one year or so of the last two years or so maybe there is practically no significant change in the transport network, so we can always apply

these growth factor methods to quickly update our matrix. So, this is the place where you have to be careful that you know that you cannot apply this growth factor based model if there is a significant change in the transport network.

But at the same time this gives you an opportunity that if I need to do short update of my matrix 1 year, 2 year, 6 months, whatever you say short period. And if there is no significant change in the transportation network, we can see the basic pattern remains the same, so we can use growth factor based methods and without considering the transportation network still we are likely to get a reasonable result, we may not be too wrong.

Effect of change in travel pattern, by construction of new facilities and new network is neglected, it is related to that, that measure of travel impedance implies have problem impedance remain constant, so obviously the appropriate change in travel pattern by the construction of new facilities that you know, both are somewhat related not exactly the same, because we are talking about the travel impedance, why travel impedance will change?

Travel impedance will change if there is a change in the characteristics if you widen the road, maybe you take say travel time as your travel impedance says for example. So, the travel time may improve if you widen the road and make a 2 lane or 4 lane road augment capacity or the demand reduces. Similarly it can increase if the demand becomes more, so the change in travel impedance is likely to happen.

Of course it can happen for other reasons but one major reason is the change in the travel pattern or change in the infrastructure. So, any impact grossly the transport network that we are ignoring.

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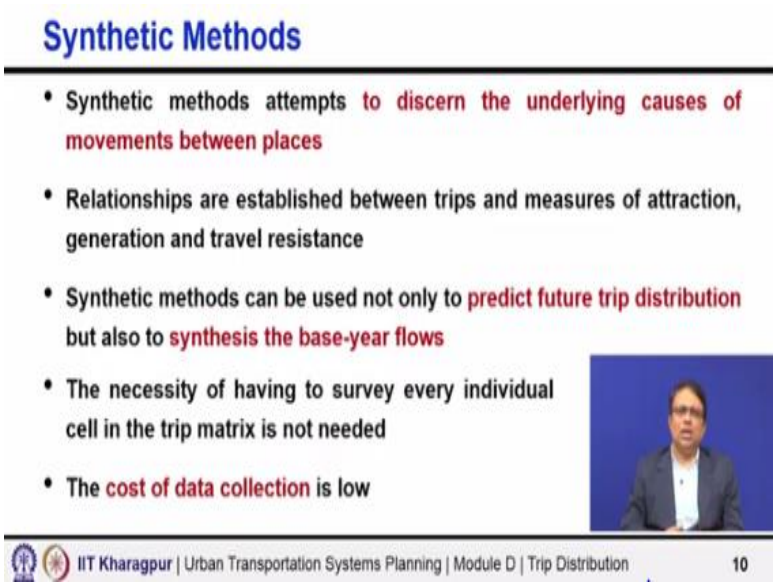

So, the main problem of the growth factor based model or the key consideration that it does not consider the reason for travel and the basic factors at the most important factor that is the change in the transport network or the transportation system is not linked or the properties are not linked while you are actually forecasting the future travel. So, nowhere there is any consideration of transport network, travel impedance and anything, any related factor.

It simply uses some multiplier in so many different ways so that your row totals and column totals give you a reasonable match and you must have the base year trip distribution matrix with you. So, we can apply a growth factor based method where there is no change in the transport network where we need and short update, but wherever there is changing the transport network and why do we really do not have the values, we want to model those values not just multiplier using a multiplier and updating it but we want to really model it.

So, there we need to go for the synthetic methods. So, synthetic methods attempt to obtain the underlying causes of movement between places. Why are more people going there? Why are less people going there? Maybe the attraction is more there. If you think of shopping they will have more shopping opportunities available there. That is why people are going more there as compared to other zones or maybe the transport system is also very good.

The road connectivity and available transport system is very good. So, naturally more people are going there. So, this kind of underlying cause is why more people travel somewhere. Why do less people travel somewhere? Why are these differences coming? This comes because of the attractions of the zones where trips are getting attracted, level of attraction of the zones not everyone has got the same level of attraction, then the travel impedance is also not the same.

I mean, whatever you can take travel time, you can take travel cause this impedance is not the same, so all these things are happening. So, the synthetic models attempt to consider these underlying causes while trying to model the trip distribution values. Relationships are established between trips and measures of attraction as I said generation and travel resistance. So, you are considering how much is getting generated, how much is the attraction of a zone and then what is the travel resistance?

So, the underlying causes are so it is more rational I should say more scientific as well. Synthetic methods can be used not only to predict future trip distribution, but also to do the synthesis of the base year flow. As I say that you know, can we model even what is happening currently? So, current our impedances are known, productions are known, attractions are known, we can try to even model these values and of course you can check, always some kind of validation is possible.

But you can model it not that somebody has to give you and only then can you apply a factor to project it as you did in the growth factor model. In this case, we can actually do the synthesis of the base year flow that is that wanted. The necessity of having to survey every individual cell in the matrix is not needed and the cost of the data collection is also low because you can do something on a sample basis and you will understand even this more when we actually talk about the synthetic models how it is developing.

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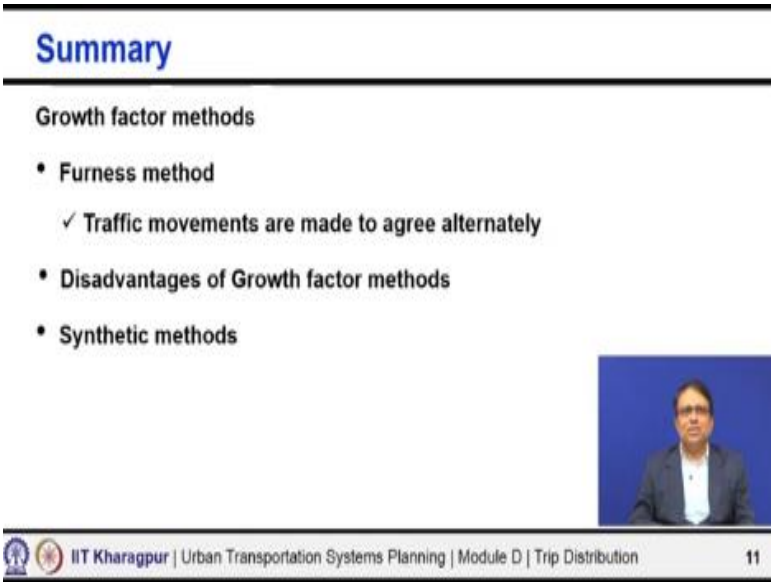

So, with this I would say that in this lecture we discussed the one more model which are popularly or widely used under growth factor based method, that is called Furness method and how we adjust the cells in the columns and rows to match the column totals and row totals respectively in an utility manner and then finally to converge to reach to an accuracy level which is acceptable and with one example also I explained it.

Then we talked about various disadvantages or limitations of growth factors based methods, particularly highlighted the underlying cause of trip distribution. That is not considered, we do not consider the properties of the transportation network and we said that always somebody has to give you the t ij value then only you can apply a multiplier to update it and there is no really physical significance or meaning to this factor except that different way people come out almost like different techniques or different ways of doing some kind of adjustment of the numbers.

So, that end of that is, only target is whether I match my target row total and column totals reasonably. So, once you know the row totals and the column totals we think that we have done our job, but the high people travel, what is the impact and that brings some kind of limitations. But as I said also that there are limitations but once we understand those limitations we can apply the growth factor based method advantages when those limitations are not really important considerations in a given context.

How? As I said, maybe there is no change in the transport network. Transport network at a city level does not change every day, maybe some small changes here and there but overall to influence have a big impact on the city travel, that kind of change will not happen every day. So, if you find that in the last 1 year or 6 months or 1 and a half year or 2 year, there is practically no significant change in the overall transport capacity or the network in the city.

Then we can advantageously use the growth factor method to quickly update our matrix for planning purposes, which is perfectly all right. But in between if the city of us got a metro. Say you did the studies before the metro was operational and now maybe in last one year the metro is operating along the length and breadth of the city, even if then it is 6 months or 1 year still you cannot use growth factor based method then you will be wrong.

So, it has the potential it has the limitation you have to judge where you can apply it advantageously and where you should not apply. And then based on that we said that what are the limitations of the synthetic growth factor based method? The synthetic methods actually overcome those limitations, so synthetic methods can synthesize even the base year travel pattern, in busier each cell valuing we can model not that always you have to somebody has to give.

We can also try to model it, consider the productions and consider the attractions in considering the impedance or the change in the transport network. So, that is what the scientific methods are, so with this closed today's lecture, thank you so much.