MCDM Techniques Using R
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Lecture –16
VIKOR Part – II

Welcome to the course and MCDM techniques using R. So in the previous lecture we started our discussion on VIKOR so we talked about some of the introductory aspect of VIKOR and then we started our discussing on the steps that are required to be executed to implement VIKOR method to do a VIKOR modelling. So let us do a quick recap of what we discussed in the previous lecture. So as we have talked about in the previous lecture that VIKOR is quite similar to TOPSIS in terms of procedure.

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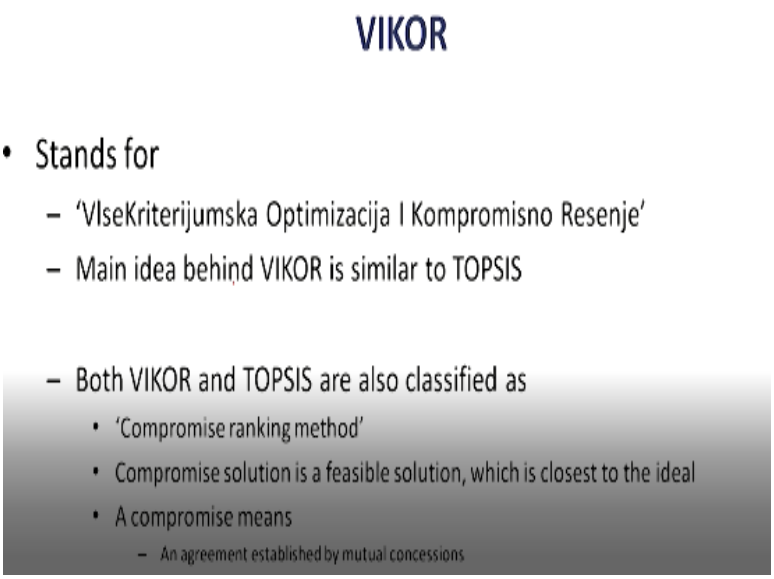

And in terms of the way you know both VIKOR and TOPSIS are classified compromise ranking method there are also classified as distance based method or you know reference based approach. So all these you know aspect we have talked about then we also talked about the you know a VIKOR what we obtained from the VIKOR modelling the compromise ranking list the solution and then the weight stability in intervals.

And all this through a ranking index which is like you know measuring the closeness of a closeness with respect to the ideal point quite similar to what we did in TOPSIS where we were

looking you know for the you know closeness of the best alternative to a with respect to ideal point and looking for the you know farthest point is the best alternatives would be farthest from the anti-ideal point. So this is also we also similar but we only focus on the ideal point.

We also talked about the IP metric which is actually used to you know define the matrix that are actually used in VIKOR. So we talked about you know SK and RK and we also talked about how these two you know measures are then finally use guys boundary conditions in the final metric that is a QK. So we also discussed the feasible solution the compromise solution and the how it is determined in terms of you know through this graphic right.

So then we started our discussion on this you know the VIKOR steps so 1st to as we talked about that best and worst f values that needs to be computed for all criteria then we can go ahead and compute SK and RK values for all the alternatives then we talked about the QK metric which is the in the introduction of a new parameter V which is the weight of the strategy to value being 0.05.

So we talked about how a balanced approach is taken in terms of these 2 boundary measures SK and RK. And how this weighted sum based on you know SK and RK is computed here. So this also we talked about in the previous lecture then you know these three measures S R and Q they can be you know sorted and we will get the ranking list however our focus is mainly on the Q which is the main major in VIKOR for obtaining ranking.

So then the last step of VIKOR is the most important one which you know it started a discussion on it so how do we you know propose a compromise solution. So we talked about that alternative A dash it can be different you know rank based using major Q. So as we said that we typically focus on this Q based ranking so 1st we look at the sorted list that is produced based on Q values.

And will obtain the you know 1st rank alternative which is A dash so the minimum value of Q is actually the 1st ranked alternative now to accept this alternative A dash the 1st triangle alternative based on q as the compromise solution two conditions are to be satisfied C1 and C2. So in the previous lecture we were discussing C1 so when C1 is about.

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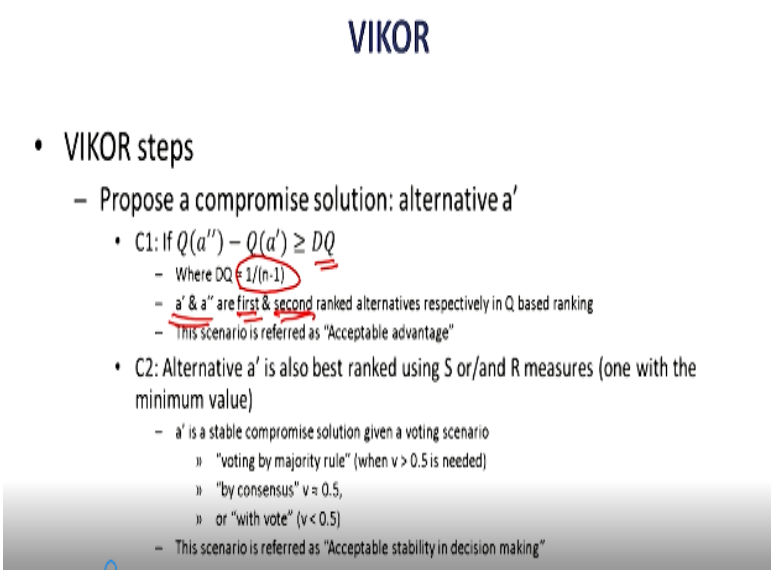

If Q double dash times Qa dash this would be >=DQ where as we talked about in the previous lecture that A double dash is 2nd ranked alternatives and A dash is 1st rank alternative. So this you know difference between the Q value of these two alternatives would be you know within this so it will be greater than this acceptable value so this scenario is referred as acceptable advantage.

So if the 1st rank alternative is having higher value then you know this much higher value of then in comparison to a 2nd line alternative then we can accept this our 2nd rank 2nd condition should also be satisfied so what the 2nd you know conditions C2 is about so here the alternative a dash should also be ranked you know best using S and R measures. So S and R measures there also you know the ranking is based on you know.

We identify the alternative with the minimum value so that would be 1st you know ranked alternative just like you know Q just like you know ranking based on Q so S and R also we can do the same and we have to check that the alternate a dash which is what one would be the you know 1st rank alternative based on Q rather it is the same case in you know for S and R so if this is also satisfied then we can go ahead and accept A dash as the compromised solution.

Let us talk about different scenarios for C2 so A dash is actually stable compromise solution given a voting scenario. So we talked about that VV being the wait for the strategy so here you can see different scenarios that could be there for a different strategy. So voting by majority rule is only accepted than the value of V is to be >0.5. If the voting is by consensus than value of v would be approximately 0.5.

If even you know lesser vote, then you know 0.5 is accepted with vote then the alternative with the largest number of work kind of scenario would be taken as the compromise solution. So these are 3 scenarios that could be there and different values of v would actually indicate this you know these scenario however when we say that stable compromise solution what we essentially looking for is that the alternative that is to be decided as the best alternative.

It should be same in S R it should not be just in Q it should also be reflected in S list or R list or in all three list so either Q and S or Q and R or Q S and R. So if all three you know list a particular alternative a dash is you know a ranked best then we can say this is a stable compromise solution so across you know ranking it comes out to be the best one. So this is what the scenario is referred as acceptable stability in decision making.

So 3 different measures as R and Q and if all 3 you know ranking list based on these 3 measures if the proposed alternative is comes out to be the best then we can accept this stability. So two important aspect of VIKOR method is that the ranking and the compromise solution that we produced is be the advantage rate. So you can see our DQ this is indicative of the advantage the acceptable advantage rate and then the acceptable stability in this.

That is also part of VIKOR so the proposed solution will actually reflect these two aspect as we will so what happens if either of C1 or C2 is not satisfied then how do we go ahead in terms of proposing the compromise solution. So if you look at the previous 2 you know condition that we talked about C1 and C2 it is C1 which is more important.

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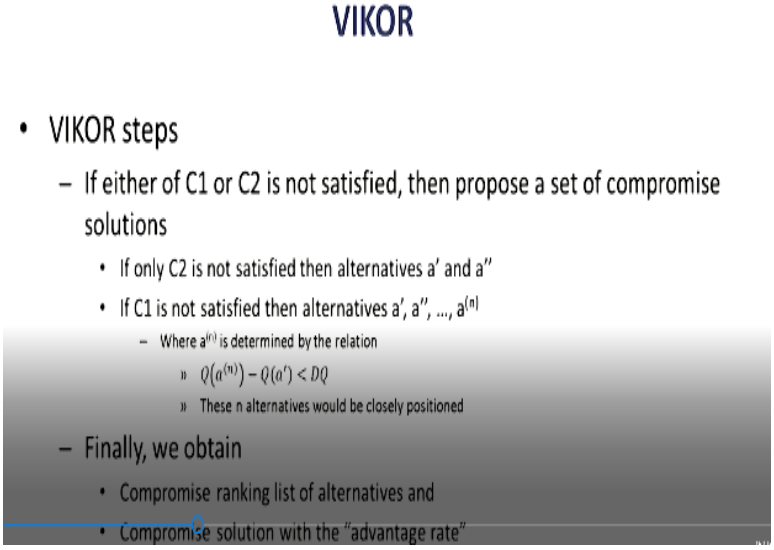

And C2 is a more of a complimentary condition. So only C2 is not satisfied then you can see that alternatives a and a dash a double dash can be proposed as the compromise you know solution. So it would be not just a solution a set of solution so a dash and a double dash as a set will be proposed as a compromise solution. So this is the scenario if only C2 is not satisfied that means acceptable stability is not there but at least you know because C1 is satisfied at least a is a dash.

And a double dash you know they can be proposed as the compromise solution. But what if C1 is not satisfied then we have to look for alternatives starting from a dash a double dash to an. How do we know where to stop how do we determine this an so this is determined by this relation as you can see in this slide Q of a and- Q a dash so the difference would be in the 1st rank alternative and the nth rank alternative that should be < DQ?

So therefore you know these alternators they would be you know you know positioned quite close to each other. So therefore it makes sense to you know propose all these alternatives as the set of you know solution. So these n alternatives would be closely positioned and therefore these alternatives can be a dash to an they can we proposed this compromise solution. So this is the this was the last step in VIKOR.

So finally what we obtain is a ranking lists top alternatives and the solution with the advantage rate right so the these are the you know you know main steps of VIKOR and you can clearly see

how it is different from TOPSIS. However, both these techniques there you know quite a bit similarity in terms of procedural steps however there is some big differences as we will. So what we will do now we will open R studio and whatever we have learned through these VIKOR steps.

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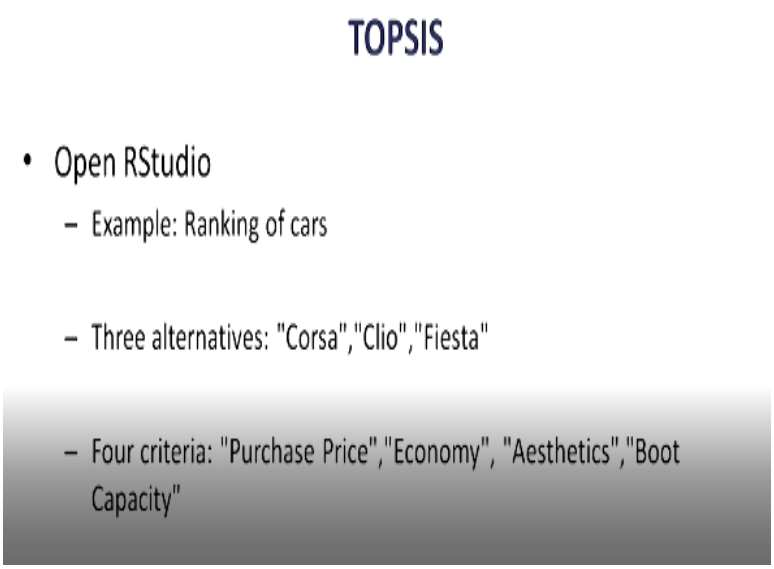

We will try to implement in an R studio exercise so the example that we are going to take is the same one like we did in a you know in TOPSIS ranking of cars. So we have these 3 alternatives and we have this whole criteria so the same data set the same example we are going to take. So let us open R studio.

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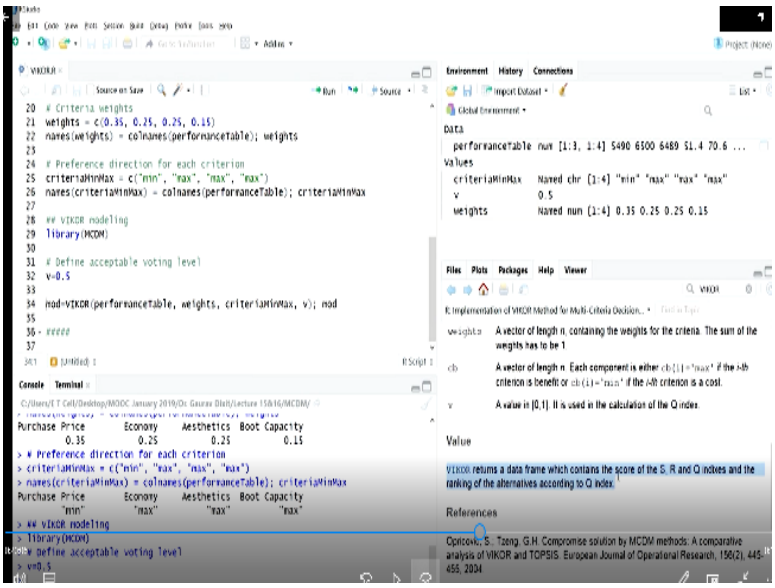

So VIKOR in R it is actually implemented in MCDM package so that is the only package that has VIKOR implementation. TOPSIS as we talked about we had 3 packages for TOPSIS so we saw I know 3 exercises for TOPSIS in that lecture however this is just one package we have you know for this VIKOR. So the goal is ranking up cars so we have 4 criteria purchase price, economy, aesthetics and boot capacity and then we have 3 alternatives right here.

So just like in TOPSIS 1st we need to have has we need to have these scores and performance table so as you can see here we are going to use this car matrix function and within the matrix function the 1st argument we are trying to generate using another function that is C. So with respect to these 4 criteria that we have you can see the values have been given there and this matrix is going to be a 3*4 matrix

Where 3 is the number of rows which is =the number of alternatives. Alternatives are going to be displayed on the row side and you know criteria are going to be displayed on the column side all right. So we have 4 criteria this becomes 3*4 matrix. So let us run this code so you can see here on the matrix has been generated and you can also see that cross column 1 cross along the column 1 the values are in similar range.

Column 2 values are in similar range similarly for column 3 and column 4 this is how you are going to actually cross check whether the way you wanted how your matrix to be generated whether it is coming out to be the same. Now we can also define the row names and column names after the alternative and criteria names so that we can easily identify which value is associated with rich criterion and which alternative.

So we can see this matrix and how the values are associated now criteria weights so sum of all these criteria weights would be 1 so we can see here now weights are being you know any slides using this combined function C function if you sum all these values at 0.35+0.25+0.25+0.15 so this comes to be 1. So these are the weights that are being given so if you look at the values 0.35 this is the highest weight.

So highest weight is being given to the purchase price so decision maker they would like to give our highest you know preference for the purchase price criteria followed by you know economy aesthetic having the 25% 25% weightage and then the boot capacity is the last one so let us see this like this so this is weights is now done now let us also rename the you know these values so that we will get to know which value is associated with which particular category.

So now we have created the matrix with performance this code and also weights for criteria. Now let us move ahead now just like other techniques also we need to specify the preference direction for each criteria so whether you know a particular criteria is representing benefit or whether the criterion is representing cost. So if it is it representing benefit than it is to be maximized if it is representing cost than it is to be minimized.

So that has to be indicated using another variable here so there is a variable that we are using is criteria minmax so here again we are using the combined function the C function and for each of the you know criteria we are going to indicate this direction. So 1st one is min so because this is purchased so we would ideally like to minimize the price of a car and so therefore min has been given so this is this criterion is actually a representing cost.

So we would like to minimize it okay then we have economy so this is a performance parameter so we would like to maximize this so therefore with respect to economic criteria max has been indicated similarly for aesthetics and boot capacity so these are also 2 parameter of car which we would like to you know maximize. So let us initialize this variable as we will criteria min max and names of let us also associate names.

So that we will know which criterion is associated with which preference direction. So you can see here now the package as we said for VIKOR modelling the only one package that we have in our environment is MCDM so let us load this library so this is loaded now we talked about in our discussion that there is this parameter v so we go back to discussion so we talked about this and that different scenarios for v.

So here you can see how working by majority rule so v would typically be >0.5 voting by consensus so v is approximately 0.5 or 0.5 just 0.5 or with vote then it will be <0.5. So here we are taking v as 0.5 this is the typical value that v has taken VIKOR. So for our exercise we are taking v as 0.5 so let us also initialise this here also has this value is going to be used and the computations and VIKOR.

So now we are going to build our VIKOR models so here you can see VIKOR function is available within this library if you want to understand more detail about this VIKOR function you can go into the help section here and we will just you know type VIKOR and we will get the details so VIKOR so just type VIKOR so you can see here in the help section VIKOR is part of MCDM package.

So this is what implementation of VIKOR method for multi-criteria decision making problem so if we look at the usage of VIKOR so there are 4 arguments as you can see in the help section 1st one is decision then weights and then cb vj. So decision is nothing but decisions values of matrix of the m alternatives for the n criteria so that we have already generated the performance statement that we have.

Then the 2nd argument is weights so this is the vector of length containing the weights for the criteria. So some of the weights has to be 1 so this we have already you know checked there so this has been generated then the 3rd argument is cb so this is actually a vector of length n each component is either cb I max or if the criterion is benefit or min if the criteria is constant. So this part also we have already initialized this part we have checked.

And the 4th argument is a value in the range of 0 to 1 so this is v this is our part of the calculation of Q index as we have talked about. So these kinds of details you can always find in the help section and once this function is called so what is the you know values which are going to be written so you can see here a value a VIKOR returns a data frame which contains the score of the S R and Q indexes.

So we will get you know the scores of these 3 measures S R and Q and also the ranking of alternatives. So this is the output that we are going to you know produce if we use this particular function so let us go back to our model so 1st argument is performance table as we have already created and then weights then criteria min max and v. So let us run this so now here you can see we have you know the column number.

So in the 1st column we have alternatives 1 2 3 and the we have the values for S so for alternative 1 is 0.4 then alternative 2 is 0.66 for alternative 3 0.725. So from this particular list it seems that the 1st alternative is the best one. We look at the you know the R values then alternatives 1 0.25 alternative 2 0.35 alternative 3rd is quite close value to alternative 2 this is 0.346 our best is alternative 1.

If we go by the Q values which is the main matrix in VIKOR so this is 0.00 for alternate 1 so this is the lowest so alternative 1 seems to be the best alternative. Then the value for alternative 2 is 0.899 and value for alternative 3 is 0.98. So we go by we follow the steps that we talked about in our slide then we just look at the list to by Q values then alternative1 is the best one and if we check the 2nd condition.

So let us 1st check the you know 1st conditions if you look at the difference of 2nd best alternative so this is 0.899 and the 1st alternative is 0.00 so the difference is 0.89 and we look at the you know what would be the DQ value. Since the number of alternators here is you know 3 so if you compute the DQ value it comes out to be 0.5 so you can check back the formula again let me show you so this is the formula for DQ 1/n-.

So since we have 3 alternatives so it will become actually 0.5 so if we go back so difference between 1st alternative and 2nd alternative this is a greater than you know 0.5 and if we look at the 1st condition C1 so this is what we actually is we actually wanted so there is a difference between 1st and 2nd alternative and 1st alternative is >the value of DQ. So you know for condition 1 is satisfied.

So if we look at the 2nd condition which says that the alternative a dash should also be the best alternative at least you know as all are and if it does not work then even better. So we can see here in the list produced R values and the list produced X values also the alternative 1 comes out to be the you know the best alternative so therefore this acceptability condition that is there you know acceptability you know stability this particular that we talked about.

So both the condition are satisfied C1 and C2 both are satisfied. So therefore we can say that compromise solution as per VIKOR model here is this 1st alterative Corsa car. So this is the modelling this is how we can actually do our modelling far VIKOR in our environment so as you have seen here using this VIKOR function we need to have these 4 arguments these codes and then the weights for the criteria and then the preference direction for those you know criteria.

And then the value of parameter v so with that we will get you know the values for these 3 measures S R and Q and by analysing the results of these results we can find out if the conditions C1 and C2 are satisfied or not and then we can confirm our compromise solution so this is how this can be done. Now let us go back to our discussion so we will discuss a few more points about you know VIKOR

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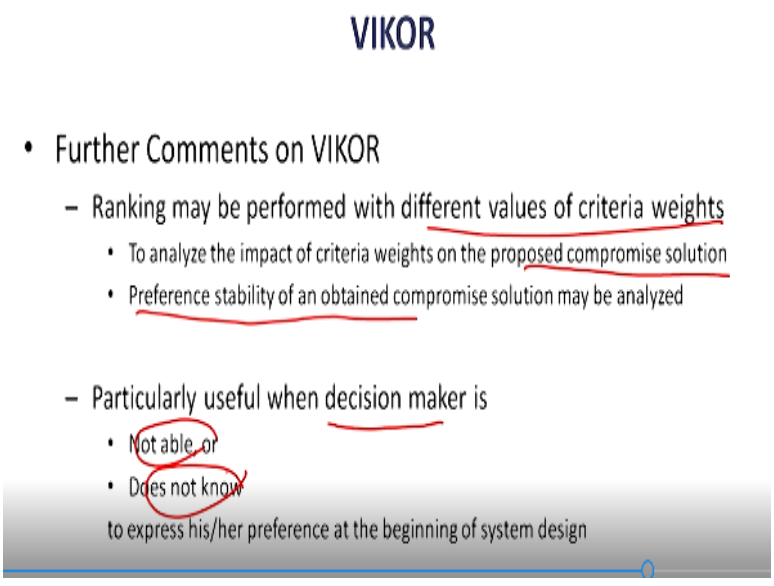

So few important aspect of VIKOR that we can discuss here is that ranking maybe performed with different values of criteria weights. So as you have seen in the function that we have even in

R environment is there that criteria weights are being taken as an argument in the function. So therefore we you know we can always change the criteria weights and again do the modelling and we will get the results.

So therefore it is easier even in R environment as well to analyse the impact of criteria weights in the proposed compromise solution. So this is akin to you know sensitivity analysis that we talked about preferences stability of an obtained compromise solution so similar point that we can change the criteria weights and look at the you know interval for those weights where the compromised solution is not going to be changed.

So this is one aspect of VIKOR now when this particular technique would be useful so you know important aspect of VIKOR we have really talked about that it just not produces the you know ranking list or best alternative it will also give us the advantage rate. So that is one aspect of that we have already discussed however if the decision maker is not able to or does not know you know their preference.

You know at the beginning of you know the decision problem that they have then probably VIKOR can help in that sense right so this is one you know aspect where VIKOR can be useful.

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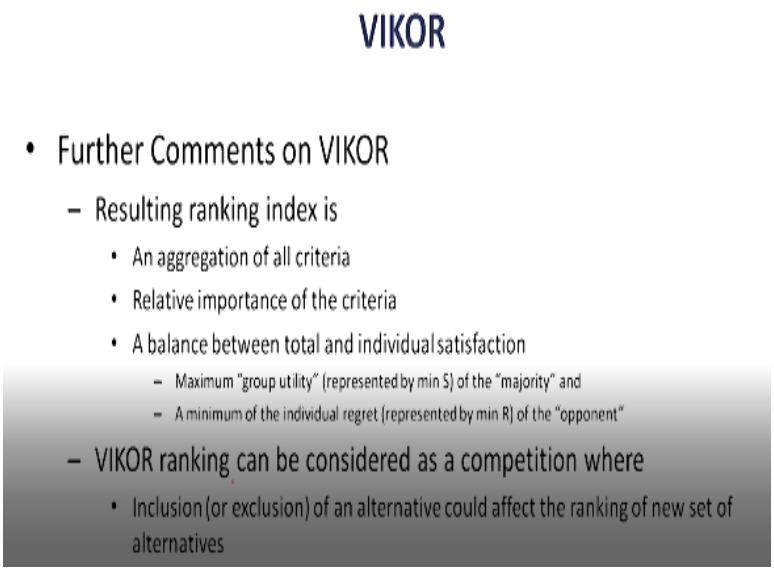

Now we will look at the you know results that are obtained through VIKOR the resulting ranking index so we will look at this is an aggregation of all criteria remember how we you know how the expression SK how the measure SK is formulated mathematically. So if you remember that and then the member QK and then RK we will get the idea that you know this is an aggregation of all criteria quite similar to the other techniques that we have discussed so far.

Then relative importance of the criteria so that is also part of it right so as we have seen in the steps a balance between the total and individual satisfaction. So in the QK measure we talked about so there we saw that a balance between you know maximum group utility and a minimum individual satisfaction that was incorporated in the way QK was you know formulated mathematically right.

So maximum so a maximum group utility represented by min s of the majority and a minimum of the industrial regret of the opponent. So balance between these 2 is also you know part of this VIKOR modelling and the resulting index that we produce then VIKOR if we will look at VIKOR you know more you know conceptually so this can be considered as a competition we are inclusion or exclusion of an alternative could affect the ranking of new set of alternatives.

So because the way it is the way procedure is implemented the comparison with the ideal solution or all the alternators being compared with the ideal solution and the way whole approach is taken right so in that sense this is this ranking is like a competition and if you introduce a new candidate there in terms of a new alternative then of course it is going to impact the final result.

Now because of a similarity in terms of procedure and in some in terms of the way they are categorized we need to understand and compare these two techniques VIKOR and TOPSIS

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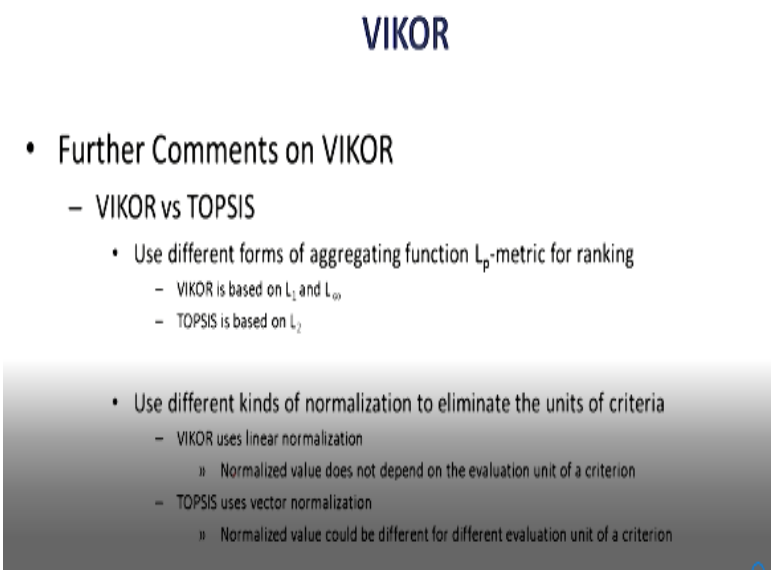

So we talk about in terms of the aggregating approach that is part of the procedures of these two techniques so aggregating function same this is based on Lp metric but different forms. So if we look at VIKOR this is based on L1 and L infinite however look at TOPSIS it is based on L2 so you remember that in TOPSIS we had used Euclidean distance formula also and the way the final you know the closing ratio was you know formalized.

So that is actually beating close similarity to L2 so definitely forms of aggregating function Lp metric was used and these two techniques different kinds of normal ideation are done to eliminate the units of criteria. So VIKOR is we actually use it as a linear normalization so what is the advantage of linear normalization is the normalized value that we get that do not depend on the evaluation unit of criterion.

However, we look at TOPSIS it usually the vector normalization so the normalized value could be different for different evaluation unit of a criterion.

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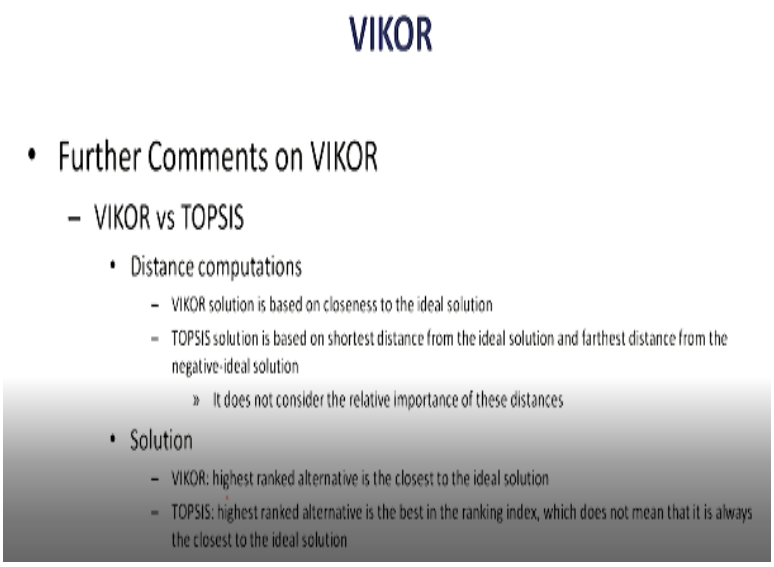

So this is how the normalization approach is different in these two techniques and we look at the you know distance computation that is there so as we talked about Lp metric the way it is formulated it is like a representation of distance between the alternative and the ideal solution right. So this how distance is actually computed and these two techniques let us discuss this. So VIKOR solution is based on closeness to the ideal solution.

However, if we look at TOPSIS it is based on the shortest distance from the ideal solution and farthest distance from the negative ideal solution. So therefore two distances are incorporated in TOPSIS whereas we only focus on one distance one type of distance in VIKOR. So in other you know issue with TOPSIS could be that it does not consider the relative importance of these two distances.

So you know how the distance from the ideal solution and how they distanced from the ideal solution how that importance how the relative importance is to be determined so that is actually not I know that is actually one issue in TOPSIS. If we look at the solution that are obtained from these two techniques VIKOR we get the highest ranked alternative which is closest to the ideal solution.

However, in TOPSIS we get highest rank alternative which is you know which is best in the ranking index. So this because two distances are part of the solution the way this solution is

generated in TOPSIS it is not guaranteed that as per the ranking index in TOPSIS is the best alternative that we get is always going to be closest to the ideal solution. So that is one difference over there.

So with this we complete our discuss on VIKOR and in the last lecture we will start our discussion on another MCDM technique thank you.