Project and Production Management

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Lecture - 6
Project Selection

The title for today's lecture is project selection. If you recall, till now we have considered the first stage of the life cycle of a project. We have looked at phases like project identification project, appraisal and the ultimate of this exercise is to select a suitable project, so that you can implement that particular project and achieve your objectives. So, today we are going to be talking about this important phase of project selection.

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We have already identified a number of projects and we have in fact appraised them. It means we have established many financial and other indicators for these projects. So we are going to look at this particular problem of project selection in a little greater detail. Now the basic problem in project selection is that there are invariably a number of criteria involved and in selecting a suitable project, one has to take cognizance of this fact and also the fact that a project will not necessarily perform uniformly well on all the criteria. If this was so, then the selection would be a rather trivial exercise.

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A typical multiple criteria we have mentioned in a project could be the investment, the return which could be measured in terms of the internal rate of return, the payback, the net present value. The risk of the project which could be identified either in terms of the probability distribution of outcomes or it could be measured on a subjective scale of high low or medium risk, future growth prospects, and similarity of the project to the existing business and the environmental implications. So all these are instances of the various criteria which are relevant in a particular project and with which we have to deal with.

Now what can be done is that this evaluation of project, in this particular course of the evaluation of projects as I just indicated would rarely be true, that one project emerges as the best one on all the chosen criteria. Incidentally if this happens then this would be known as a dominant project. A project which dominates all the other options if it was best on the investment front, best on all the criteria would be a dominant project and should clearly be chosen. So this is the definition of dominance. You can say to some extent, however in general there would be a set of non dominated projects, the choice out of which is not normally easy. Why it is not easy because you might find for instance that one particular project is very good on the rate of return that is poor on the risk front. There is another project which is very good on the risk front that does not necessarily guarantee a very good return. How do you choose between these? There would be a dilemma and in general what helps you to resolve this dilemma is the management priorities to various criteria could help us in decision making with regard to which project you choose and which not to choose.

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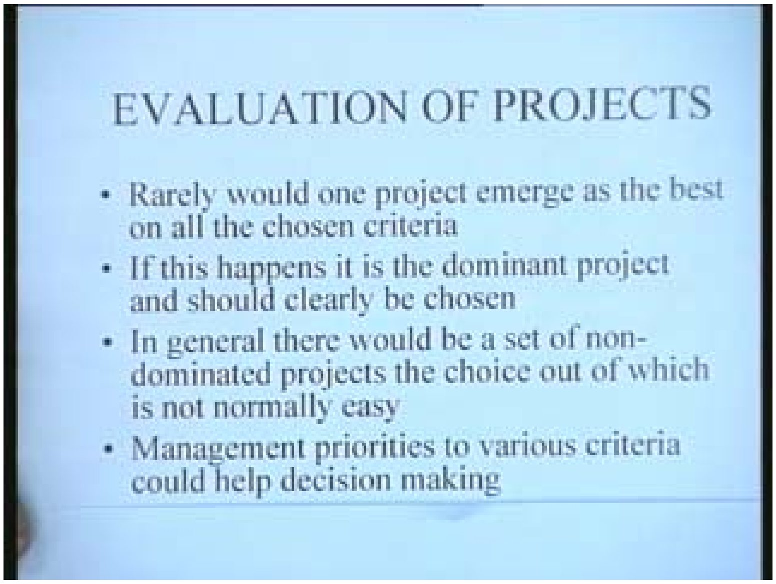

This is the broad frame work of project evaluation with which we are going to be concerned here. Now look at the criteria in a project. We have said that there could be a variety of criteria but one way of looking at criteria could be either we could classify criteria into either tangible criteria or intangible criteria because we encounter both in selection of a project. Tangible criteria could be like investment measured in rupees or it could be the return measured as a percentage. The return is 20-25 percent for a project. It could be the payback period measured in years or it could be some annual cost measured in rupees per year. So these are all instances of tangible criteria which can all be measured but again what we notice is they are not necessarily in the same units. So they could either be in the same units and they could be in commensurate units or they could be in incommensurate units.

For instance the payback period in years cannot be treated in the same lines as the internal rate of return as a percentage. You cannot add them algebraically and perform all those operations which you would normally like to perform on criteria which were commensurate. On the other hand we have intangible criteria. Intangible criteria are those criteria which are not measured, not measurable on a well defined scale. So when you are talking of for instance a criterion like say similarity to existing business, it would be very difficult for a firm to give a quantitative criterion or a quantitative value of how the new project would be similar to the existing business. You might say it is poorly related to the business or it has a high degree of similarity with the business or you could think at best of a subjective scale. So although these are not measurable you could at best use a subjective scale of may be a 0 - 9 or 0 - 100 as the case may be and develop a scheme of rating these on that particular scale.

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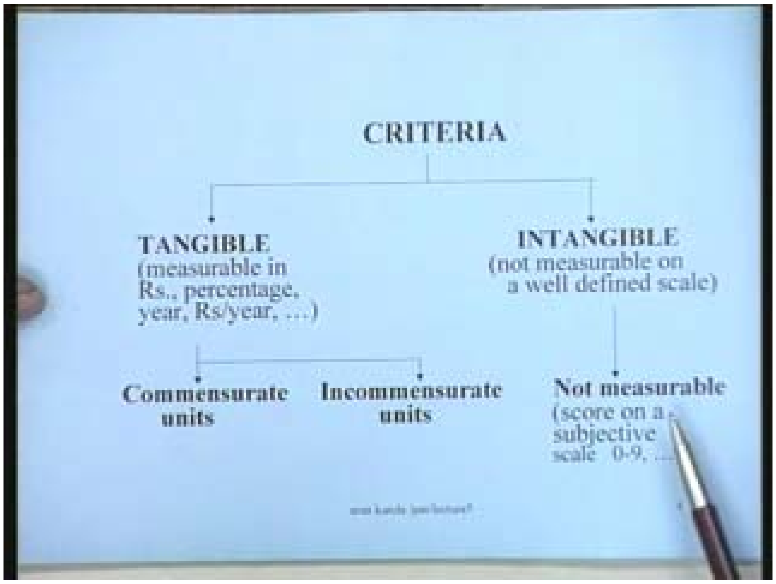

In the process when we are choosing different projects, projects have their attributes which are either commensurate or incommensurate or they are dealing with intangible criteria. So we deal with this particular problem and all of this is under the gamete of what we call multi criteria decision making. So, all the principles of multi criteria decision making would in fact come handy. When one is trying to choose a particular project from this particular point, essentially what we try to do is we try to structure the problem in the form of a decision matrix. Decision matrix is nothing essentially; conceptually it is a listing of the various project alternatives. So we have project 1, project 2 and so on up to project m. If we assume that we have m project alternatives, which we want to compare on various criteria C_1, C_2, C_3 and so on up to C_n. So we have n criteria on which we want to compare. Now based on the subjective scale that we were talking about, we could always convert the intangibles into some kind of a numerical score. So ultimately what we would do is for each of the criteria we would have an evaluation. For instance the first project of the first criteria would have an evaluation x_{11}.

The first project on the second criteria would have an evaluation x_{12}. The first project on the nth criteria would have an evaluation x_{1n} and our objective is somehow to be able to take care of these evaluations on individual criteria and come up with a consolidated score for the project P_1 and do something similar for the project P_2 and so on. So we could ultimately obtain a score for each of the projects.

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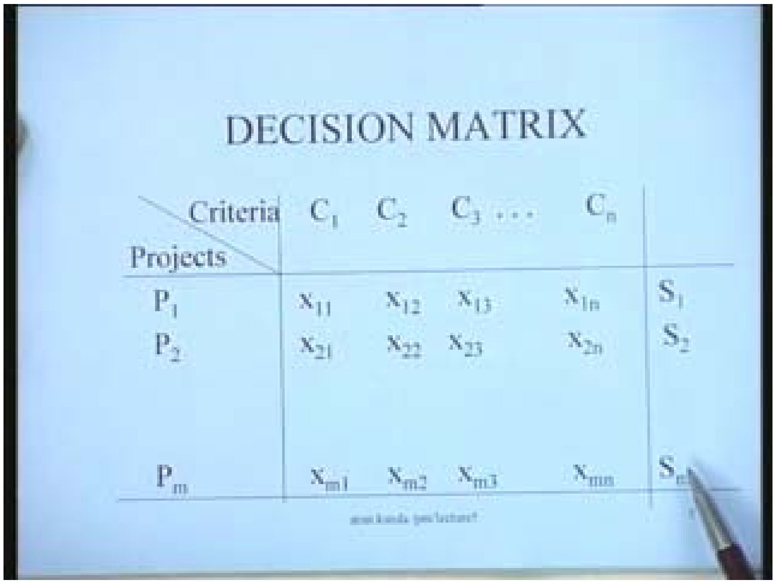

We would be able to rank the projects and may be select the best one. Now this particular idea though patently very simple has problems because these criteria even if they are measurable are not in the same units. This might be payback period in years and this might be the investment in lakh of rupees and this might be a percentage. This might be something else. Even if you have these evaluations, you cannot add these evaluations directly to obtain a kind of a score. So what is really being done is that you have to undergo a process of normalization to make sure that these score on individual criteria are comparable and there could be various methods of normalization. We would in the course of this particular lecture look at 2 procedures which are particularly useful to identify the means of adopted for normalization and subsequently obtaining a score for ranking. However we go into this procedure of the decision matrix, we eluded the concept of dominance earlier by saying that if a project was better on all the fronts, it was dominated. It was a dominant project and so on.

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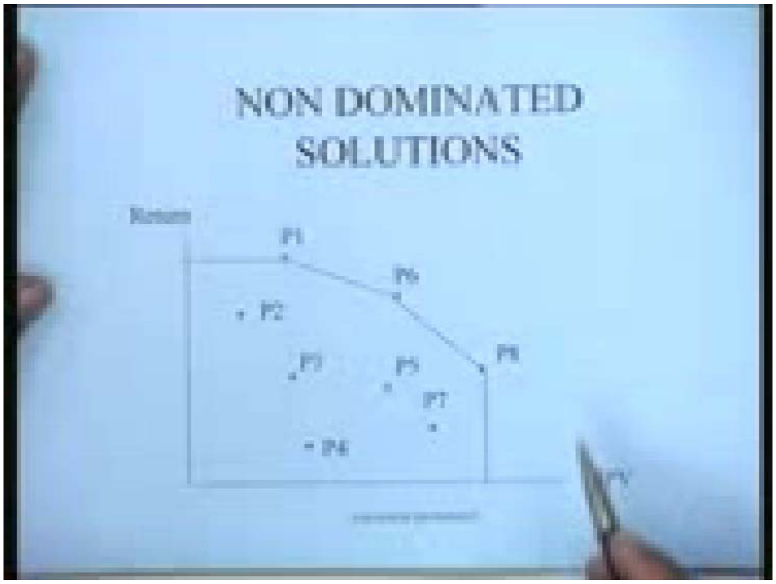

Now I have tried to illustrate here through an example with two benefit criteria. Let us look at a comparison of these 8 projects which are shown with regard to the net present value and the return. Obviously both these criteria are benefit criteria i.e., we want to maximize that. We want to maximize the NPV and you want to maximize the return. Now if you just look at the performance of these projects you find that they lay, they can be plotted as points on this 2 dimensional graph as shown here. Now out of these, you can clearly see that the project P_1 one for instance is clearly better than all. P_1 would be better than all projects which are lying in this particular quadrant. That means the project P_1 is better than the project P_2. Why? Because it has a higher NPV and it has a higher return. So it beats P_2 on both the fronts and therefore as far as this particular quadrant is concerned, the point P_1 is set to dominate all the points which lie in this particular quadrant. Similarly if you look at the point P_6, the point P_6 can clearly dominate all points except P_7 and P_8 because all these points, that is project P_2, project P_3, project P_4 and P_5 are clearly inferior to the project P_6. Similarly let us look at P_8. P_8, we find is better. It that means P_8 dominates over P_3, P4, P_5 and P_7 and yet it does not dominate over P_2, P_1 and P_6.

So if you do this exercise, we clearly find that P_1 P_6 and P_8 emerge as the only 3 points or the only 3 projects which are not dominated by any other point. So P_1 P_6 and P_8 therefore are known as the non dominated solutions which mean that if we were to make a selection out of these eight projects, we could clearly say that P_1, P_6 and P_8 are non dominated solutions because they and all the other projects are dominated by at least one of them. So it would be logical for us to conclude that if we were to select a project, we should confine our search to the non dominated solutions which is also known as the Pareto optimal solution in this particular situation. So the choice would bend narrow down to the non dominated solution but if you were to choose between $P_1$and P_6, can you make a clear distinction?

You cannot because after all what is happening, look at P_1, $P_1$is highest as far as return is concerned and is the least as far as the NPV is concerned. Out of the 3 projects which are there, now if you go to P_6 what we are basically doing is we are sacrificing some return and gaining in terms of NPV. The choice between $P_1$and P_6 would be governed by how much value, you as a decision maker attach to the two criteria that you are talking about, namely return and value. Therefore this choice would be made based on your priorities, based on the weightages that you have signed to the various criteria.

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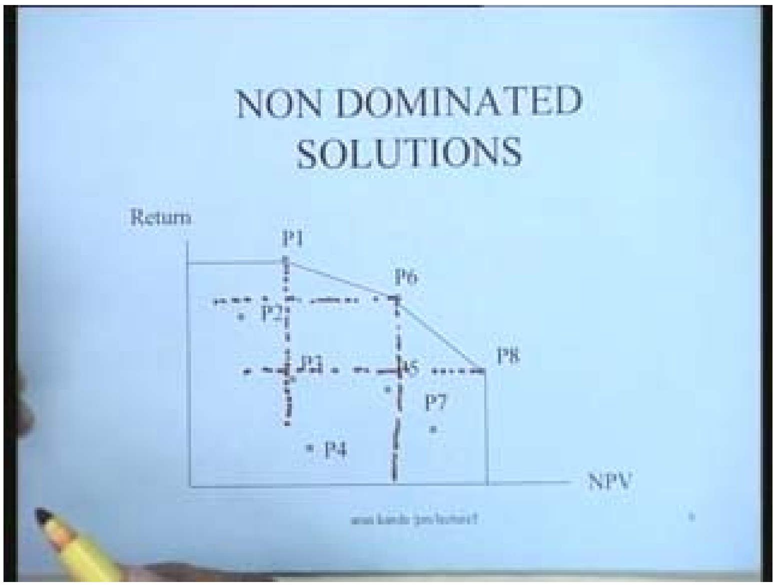

So the notion of dominance nevertheless is a very useful one because it gives us an opportunity to reduce the number of solutions and then confine our search only to the non dominated solutions but even searching the non dominated solutions in our real life situation could be a very tough job. Here we are talking about only two criteria but we could have multi criteria right? Precisely, like multi dimensional perspective how will you get it? You can have a multi dimensional perspective. If you have three criteria you could talk of three dimensional spaces. If you have n criteria you talk about n dimensional space and that is what I said that trying to identify the non dominated solutions in multi dimensional spaces would be much more difficult. But yes conceptually you are very well. So what is the preferred solution? The preferred solution is the solution that you ultimately choose. We call it the preferred solution. The preferred solution could be one out of the non dominated solution set that you have identified. It is basically the solution that you have identified ultimately. So the preferred solution could be the dominant solution if one exists. It could be the Pareto optimal or the non dominated solution set if it exists out of these or it could be the selection from out of the non dominated solutions which will involve tradeoffs and will be governed by priorities or weightages to different criteria. Like in the example when we considered those three non dominated points, the choice out of them will have to be made by tradeoffs and priorities between various criteria.

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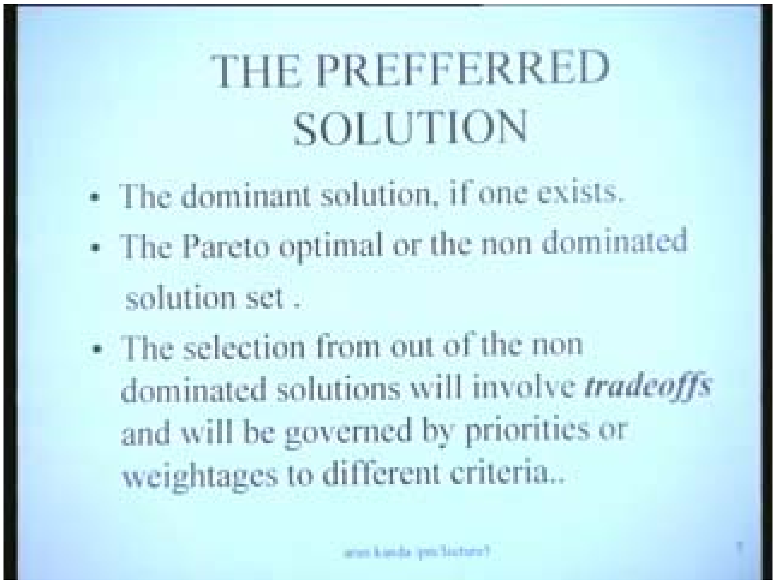

So we can look at this particular procedure in little more detail. The crux to the problem really is that weightages to criteria have to be identified. So these priorities are weights to different criteria and can be obtained by different ways. How? One common way of obtaining these weights is mutual consultations or opinion polls. You can talk to various management personnel and try to identify what they are feeling about various criteria and then try to establish the weights for the various criteria. You could do it through a pair wise comparison between criteria that means, it is much easier for instance, when you ask an individual to compare and answer between two criteria at a time, say do you consider criteria A more important or B more important? So we can I consider A more important and the difference is say medium.

Then you can assign two criteria A, may be two points and in this manner if there are n criteria, you would have n C_2 pair wise comparisons and you could then use these comparisons and from there determine the total votes given to every criteria and determine a possible ranking or you could establish a hierarchy of priorities and use the framework of AHP, the analytic hierarchy process developed by Saaty. The advantage here is that you have a well defined computer package known as expert choice which can be made use of and you can develop the weightages to be given to the various criteria through a hierarchy in that particular process. Anyway there could be other methods also, but this summarizes, you can say the manner in which weightages to criteria will be given.

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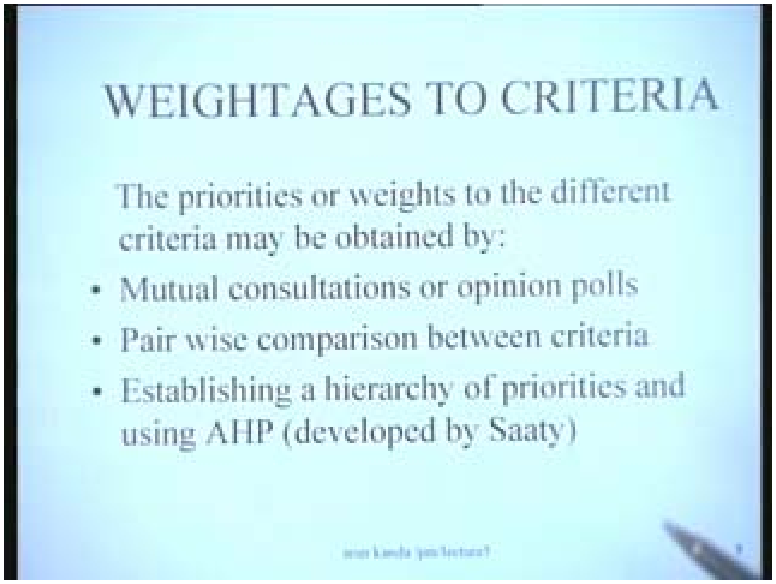

Let us look at what would be the framework for a problem. For instance if we take a project selection problem, our typical problem criteria might be let us say six criteria. The first criterion could be investment and the investment could be in lakhs of rupees and for the worst criteria it could be ten lakhs and for the best criteria it could be two lakhs. They would be arranged for because we are always talking about selection from out of a set of finite number of projects, similarly the internal rate of return for the projects that we are trying to choose. The worst possibility could be ten percent and the best could be forty percent. The payback in years, the worst could be ten years and the best could be two years. The risk could be measured on a subjective scale. It could be very high, which is the worst possibility, high medium, lower and very low which is the best possibility. Similarly the future growth could be very poor, medium, good, and very good and so we could have a subjective scale like this for future growth.

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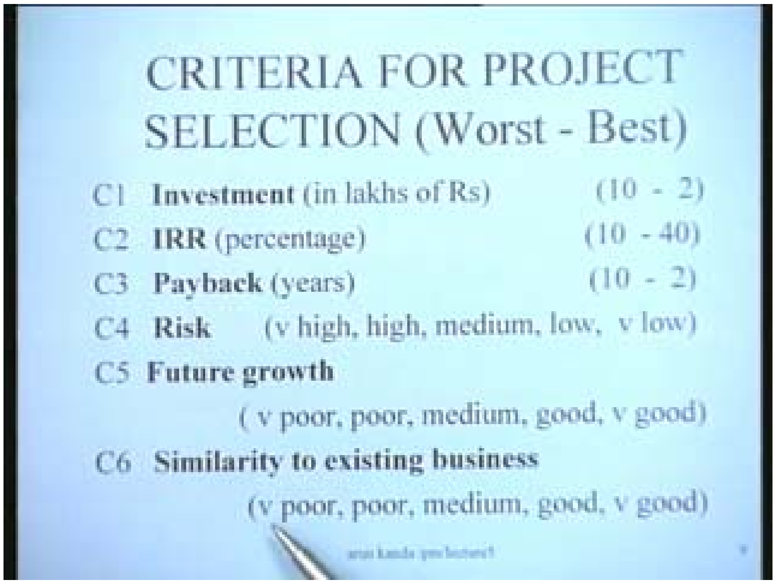

Similarly similarity to existing business could also be quantified on the form of a scale like this, very poor, poor, medium, good and very good. So what we are trying to say is that each of these criteria would go from a certain worst to a certain best and I have just given you instances of how they would go and this would help us in the construction of the appropriate scales based on this information. What we might do is for instance if we have 5 projects and we compiled the information on the six criteria which we just mentioned, that is investment, the rate of return, the payback, the risk, the future growth and the similarity to existing business.

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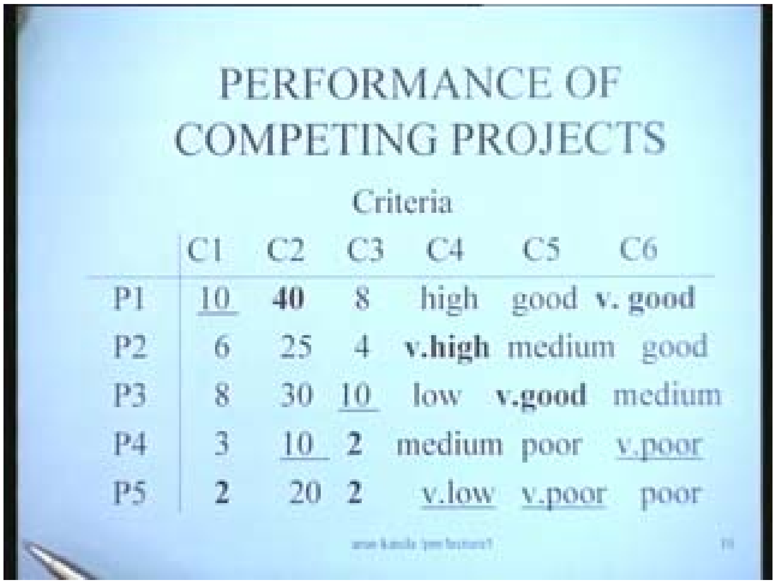

Our starting data or the starting decision matrix would something like this and just to give you an idea, we could do a similar exercise for t. This is the best option in bold and the underline one is the worst option on this criteria. Each of the criteria as it has been done, for instance for the first criterion of investment project P 5 is the best because it requires only 2 lakhs as cost investment and project P_1requires an investment of 10 lakhs of rupees. So it is the worst underline. Similarly here for all these, if you then scan this matrix you find typically, if all the bolds were in the same row, you would have a dominant project but here, we do not have that kind of a situation because what we find for instance is project $P_1$is best on these two criteria C_2 and C_6 and is the worst on criterion C_1. Project P_2 is the best on criteria C_4. That is about it. It is not worst. It is intermediate on other criteria and so on. So this would be the kind of typically scenario that you would encounter when you are to choose between different projects. You would not have a clear dominant project and therefore you are now required to choose between various projects based on this kind of a situation. Now in order to formalize these concepts we will take an example which we will try to work out. This is an example that is given by Hwang and Yoon and I am trying to use this example to illustrate two procedures which are very commonly used in project selection.

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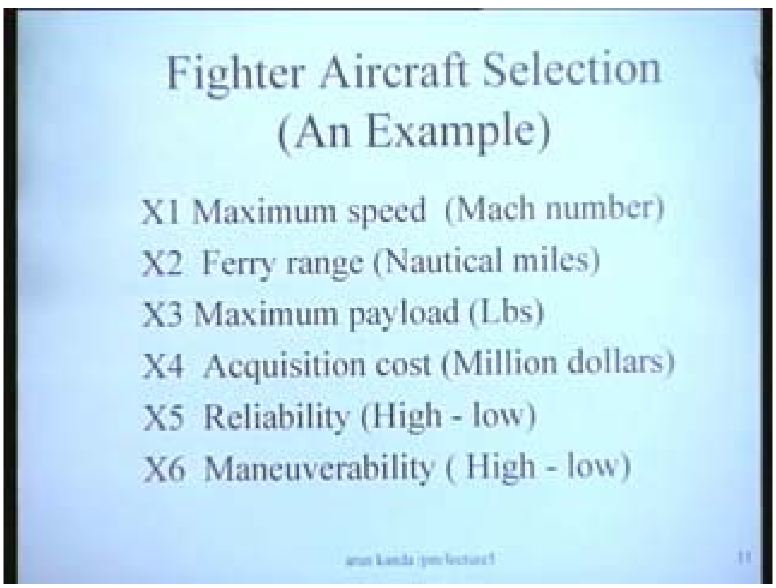

So the example is a fighter aircraft selection and the six criteria that are considered relevant for this example are the maximum speed which is measured by a Mach number of the aircraft. The second criterion is the Ferry range that the aircraft can carry without refueling in nautical miles. The third criterion is the maximum payload in pounds. The fourth criterion is the acquisition cost in millions of dollars. The fifth criterion is the reliability which is measured on a scale from high to low and sixth criterion is the maneuverability. Maneuverability is a very important aspect of a fighter aircraft because you would like that the aircraft should not be too bulky and should be easy to manipulate.

If you recall during the war that we had with the Pakistanis, one of the advantages that the NAT aircraft had was that it was very maneuverable as compared to the other aircraft which the Pakistanis had. The Pakistanis had the cyber-jacks. So that is the aspect of maneuverability. So taking these considerations we are interested in which project, where do we buy our aircraft from. That is the project. Let us suppose that there are four different suppliers, alternatives, one alternative, two alternatives, three and alternative four and the four aircraft that we are considering buying have these values for the various criteria. For instance you can find that alternative 2 is the one which can run the fastest. It has a mark number of 2.5 and it also has the highest ferry range. It can go up to 2,700 nautical miles without actually refueling. However the maximum payload that it can carry is small or it can carry only 18,000 pounds whereas the other aircraft can go up to 21,000 pounds and so on. The criteria number five and six that is X5 and X6 which are reliability and maneuverability are evaluated on a subjective scale which average low, high, average depending upon these things. So this is the sort of decision matrix for the aircraft example, notice in this particular case X4 is a cost criterion and others are benefit criteria.

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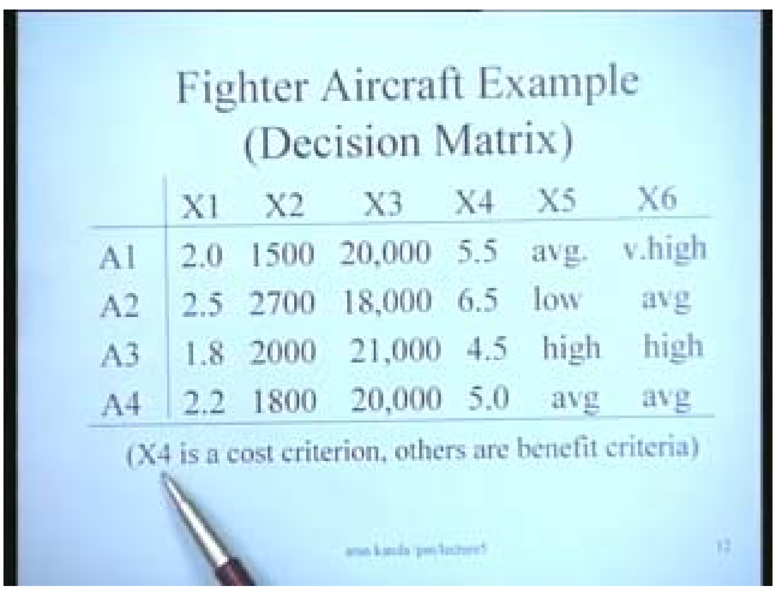
Fighter Aircraft Example (Decision Matrix)

	X1	X2	X3	X4	X5	X6
A1	2.0	1500	20,000	5.5	avg.	v.high
A2	2.5	2700	18,000	6.5	low	avg
A3	1.8	2000	21,000	4.5	high	high
A4	2.2	1800	20,000	5.0	avg	avg

(X4 is a cost criterion, others are benefit criteria)

This is the only one which we want to minimize that is the cost. The maximum speed, the ferry range, the maximum payload, the reliability and the maneuverability are all things which you would like to maximize. So they are benefit criteria. Now what is done is the first step is to be able to convert the subjective factors by using a common scale. So a common scale like this from 0 - 10 is device. For cost attributes if it is very high we give 1 mark, if it is high we give 3 marks. If it is average we give 5 marks. If it is low we give 7 marks. If it is very low we give 9 marks and we similarly notice that the benefit criteria would be very low, average, high and very high. The benefit is increasing this way because when the cost is reducing then it gets more points.

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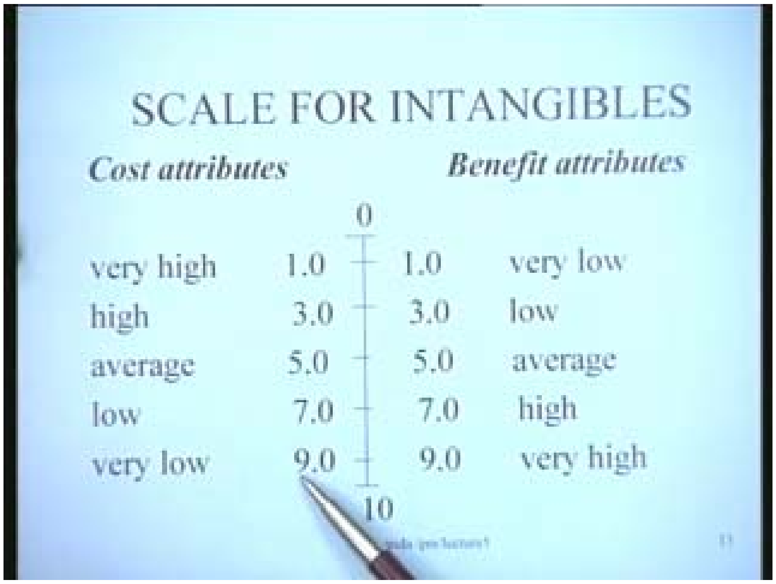

There is a difference between the cost attributes and the benefit attributes. So using this scale for intangibles, it is possible to convert that entire initial decision matrix into a matrix of numbers totally and this is what happens. We have been able to convert the information for all these four projects. Four alternative projects, four alternative aircraft to a set of numbers and incidentally I would now illustrate to you the steps of the procedure that is adopted in a program known as TOPSIS technique for order preference using similarity to ideal solution i.e., TOPSIS. This is the beginning step in TOPSIS. You obtain a matrix which is first of all in numerals but these are all my incommensurate units.

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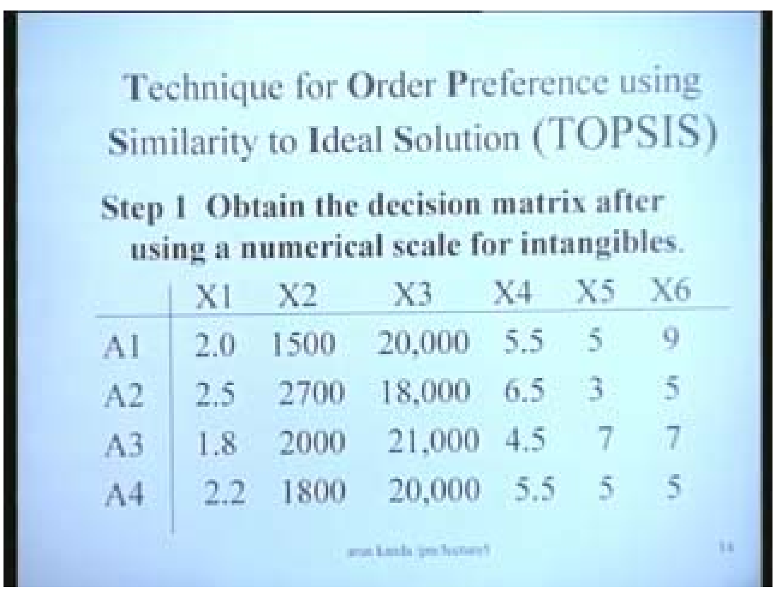

They are not in the same units. So we have to normalize this and normalization would have to be carried out by using some appropriate scheme of normalization. What is done is, in order to obtain the normalized decision matrix we use this relationship. From the original decision matrix, we obtain the normalized decision matrix R using the relationship that r_{ij} = x_{ij} divided by the square root of sum of it is equal to 1 to m of x_{ij} square. Now what is the intuitive logic of this particular number? What you are trying to do really is, let me go back to the decision matrix here.

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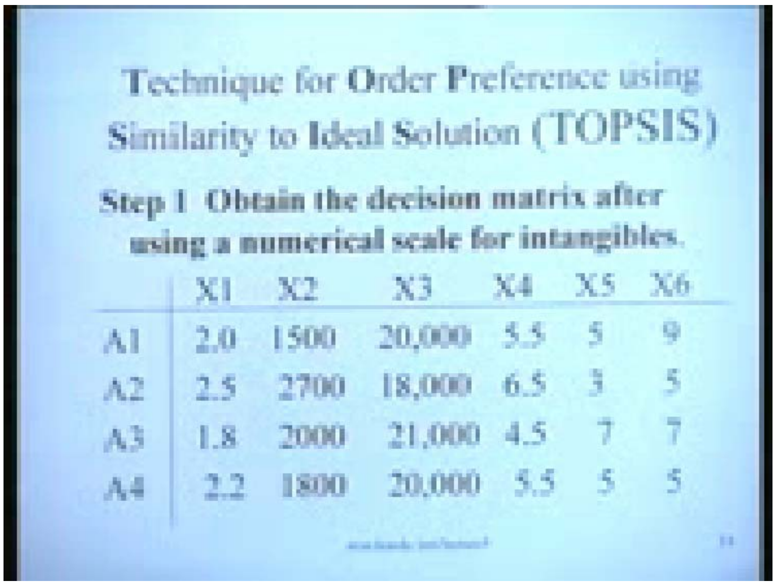

All these numbers are mark numbers. What is really being done is that if it is square of this and square of this and square of this and square of this (Refer Slide Time: 335:36) and I take the square root of the sum of the squares and then I divide all these numbers by that particular value. I would have a non dimensional number in each of this place. That is precisely what is being done. So this square plus this square plus this square plus this square, take the square root of that and then divide each one by that number. So you will make sure that you would have a number between 0 and 1 which will be a dimensionless number. So this is the scheme of normalization which is adopted in TOPSIS. So using those values we find that we would get numbers, each column is normalized in the same manner. So you get these numbers and these numbers as you can see, were all fractions between 0 and 1, the way we have normalized them.

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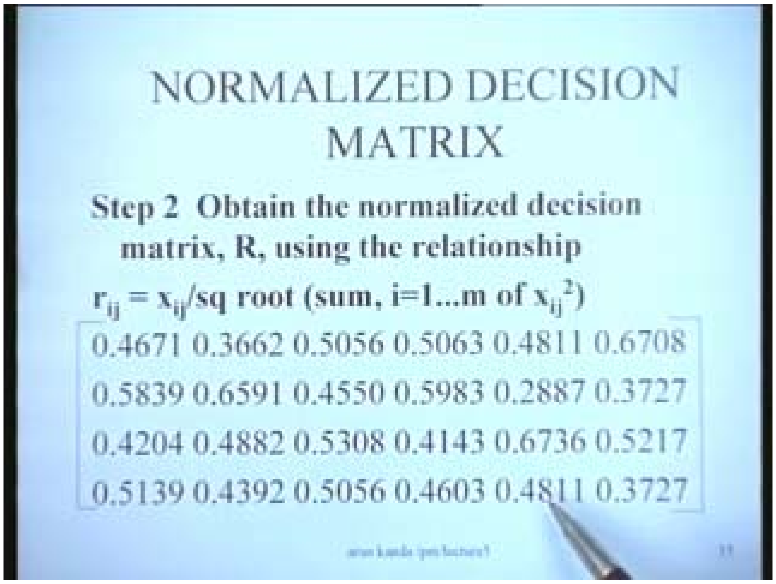

So this is the result. This is called the normalized decision matrix. Then what we do is we take into consideration the fact that these individual criteria have certain weights. So steP$_3$ is to obtain the weighted decision, matrix V, we had obtained the original normalized decision matrix R. We now obtain the weighted decision matrix V by multiplying each column of R by the corresponding weight. So suppose in this particular example the weightage given to the first criterion is twenty percent, ten percent to the second one, ten percent, ten percent, twenty percent and thirty percent. As I indicated to you earlier, these weights may be obtained by a subjective opinion poll or pair wise comparisons or AHP or whatever. Once you obtain these weights, the earlier columns you had obtained each column you will multiply with a corresponding value of the weights. So the first column multiplied with point two, the second column is multiplied with point one, third column multiplied with this, fourth column multiplied with this, the fifth column multiplied with point two becomes the weighted decision matrix and this is the result.

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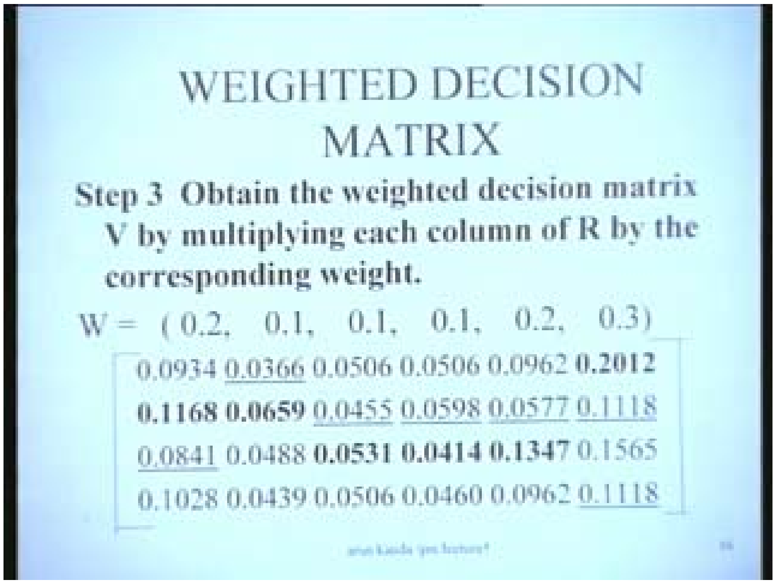

The weighted decision matrix now embodies the preferences of the decision maker on the various criteria also. So you have these values. Now if you look at this particular matrix, which is the weighted decision matrix, for instance if I identify the largest values here, this is the most desirable (Refer Slide Time: 34:33). So this now shown in bold and the least value is this one which is underlined. So the best and the worst is the best and the worst (Refer Slide Time: 34:43) the best and the worst and this is the other way around. This is the best and this is the worst, why because this is a cost criteria. The member that X4 four was a criterion all others were benefit criterion. So the least value here is the most desirable. So this is the reason why the least value in column four is shown as the best one because this is a cost criterion. So this is the best and this is the worst and of course, this is the highest so this is the best and this is the worst. This is the best and there are two worst which are at the same value in this particular situation. So we can then identify out of the weighted decision matrix, the best and the worst options which exist. Out of the existing options, we have only four options. So out of that we can determine this. Actually TOPSIS is unique in the sense that it looks at what could have been the best and what could have been the worst. Once it looks at these two scenarios, what is the best possible under the circumstances what is the worst possible under the circumstances, it tries to rate each solution as the kind of difference of how far it is from a utopia. A utopia would be the one which is the best possible. However that is the unique feature of TOPSIS.

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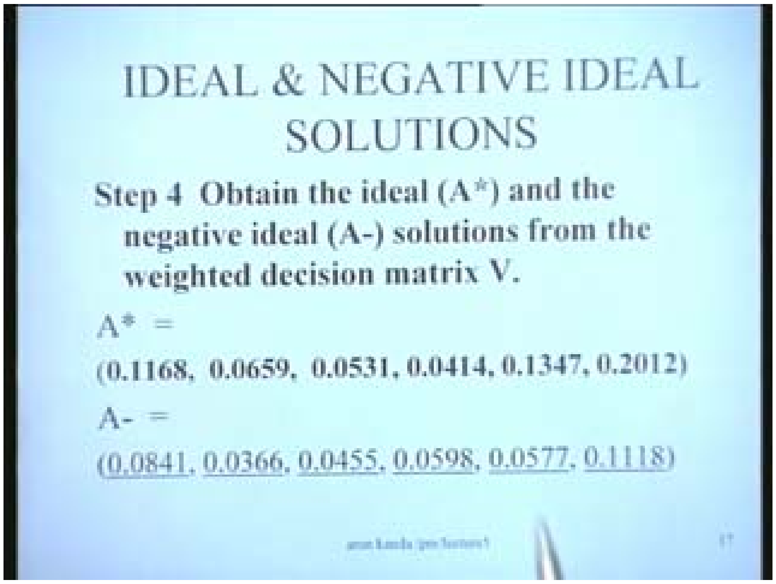

So how it is done is, in step four we identified the ideal and the negative ideal solutions. The ideal solution is denoted by A star and the negative solution which is denoted by A minus. These solutions are identified from the weighted decision matrix V which it has obtained. If you can see nothing but A star is nothing but the best possibilities, you see for instance all the bold figures which we had seen in the previous table.

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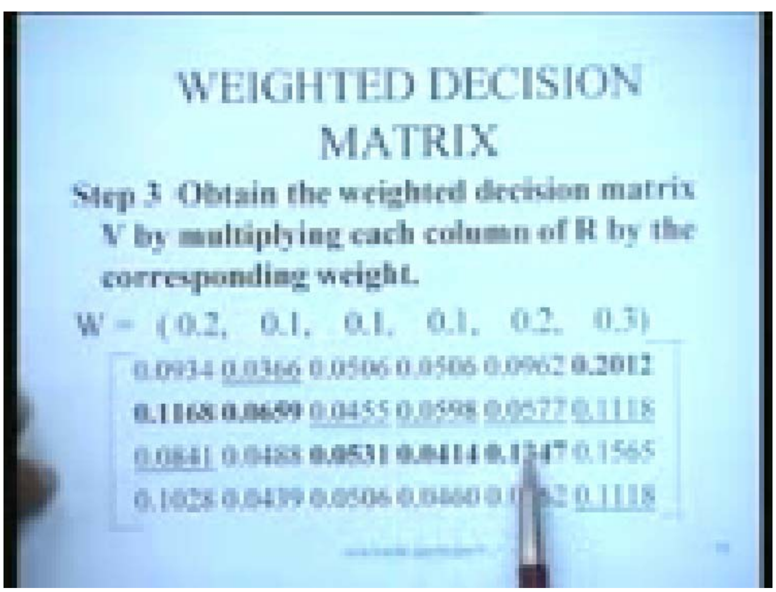

These are, look at the previous table, these are the bold figures. They were the best possible solutions under each case. So we identify this and the row that identifies the best is called the ideal solution and the row which identifies the worst possible solutions is called the negative ideal solution. So when you look at it, you have the ideal solution this way and the negative ideal solution this way.

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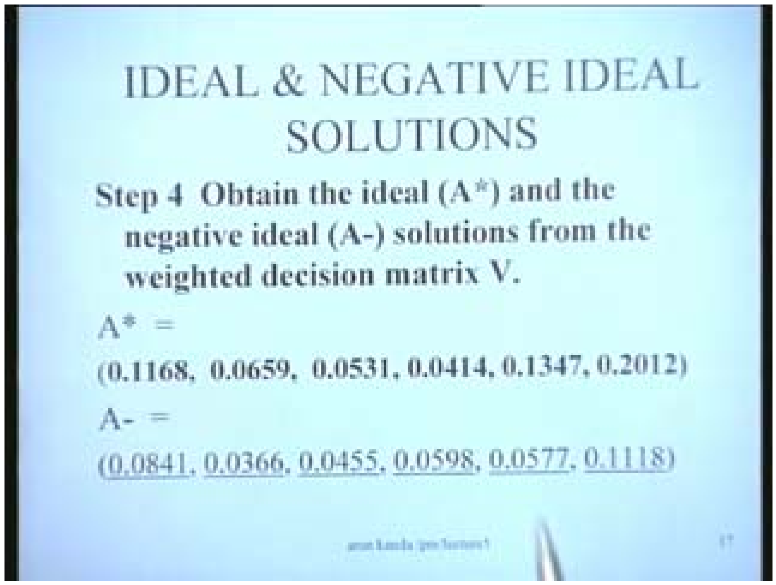

What is now being done is the solution would be identified on the basis of its distance from the various solutions. Now how is it done?

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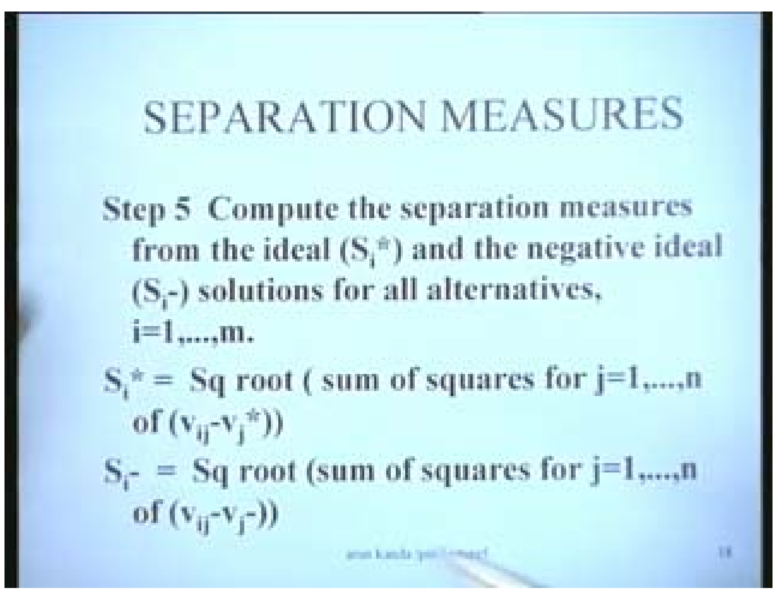

Step five is, we compute the separation measures from the ideal and the negative ideal solutions for all the alternatives i = to 1 to m, that means you are talking for each, and we have four alternatives in this case, that means there are four suppliers who are giving us the aircraft in this case, four projects. So we calculate the separation measure from the ideal as well as a negative ideal solution for all the alternatives and how it is being done is S_i star is nothing but the square root of again sum of square for j = 1 to n of v_{ij} – v_j star. I mean sum of squares of this and similarly S_i minus is nothing but, instead of this star we have the v_j – here. The square root is sum of squares for j = 1 to n of v_{ij}– v_j– whole square. That is the kind of difference that is there for both the separation measures.

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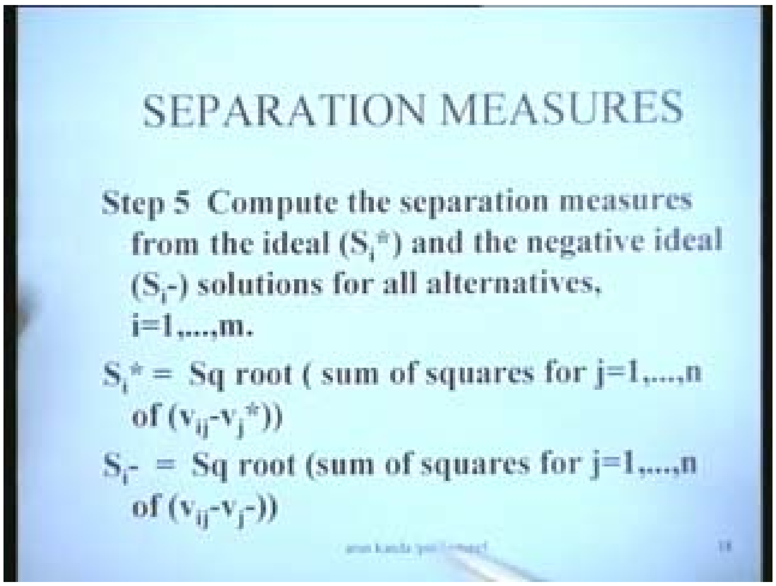

These separation measures are computed and for this particular example the separation measures that we get from the ideal solution are S_1 star, S_2 star, S_3 star, S_4 star. These are the particular values and similarly the separation measures from the negative ideal solution are S_1 – which is computed as this value, S_2 – which is computed as this value, S_3 – which is computed as this value and S_4– which is computed as this particular value.

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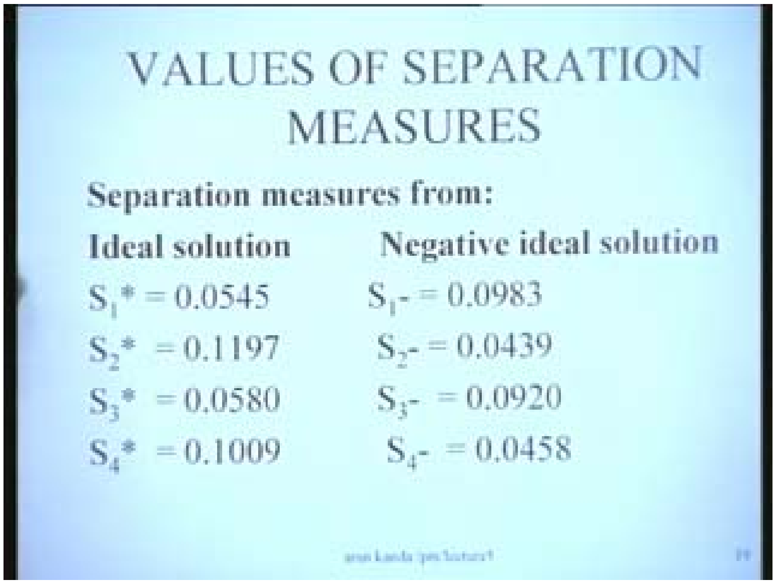

The separation measures are computed for all the alternatives which we were trying to consider for this particular case. The next thing is having computed these separated measures; step 6 is we are trying actually to determine the relative closeness to the ideal solution. So the idea is very simple. I think it is explained and is understood by this diagram. If the ideal solution is a point here, now the ideal solution is one which is like the best of everything. The best of the Mach number, the best of everything is whatever is available if it is here and mind you such a solution may not exist. It does not exist here because you do not have all the favorable features together in the same project and similarly all the negative features would be a point here which is called the negative ideal solution here. Your actual solution i.e., a particular alternative is a point here and what we are measuring is a separation. So S_i star is the separation of the alternative from the ideal solution and S_i– is the separation of the alternative from the negative ideal solution. We have measured these distances.

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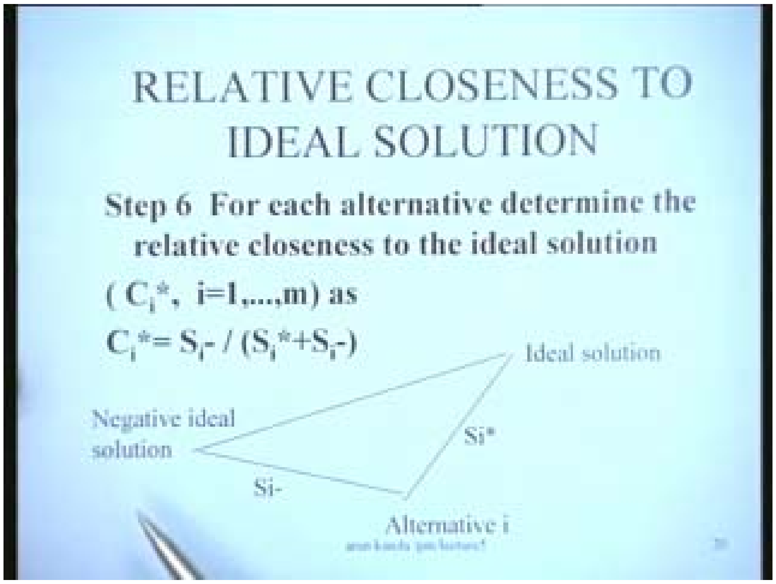

So we then define a figure here for closeness, this is the closeness of the ith alternative through the ideal solution which is S_i – divided by S_i star + S_i –. I hope you are convinced that this in fact would represent a degree of closeness. How? You can see clearly that if this alternative were coincident with the ideal solution, then S_i star would be 0 and when S_i star is 0, this value would be equal to 1. Closeness is hundred percent. On the other hand if this alternative was coincident with negative ideal solution, in that case what would happen is the S_i – would be 0 and therefore this closeness would be 0. So the closeness for each alternative, the relative closeness is a number between 0 and 1 and the value of that number, the closer it is to 1 show that you are closer to the ideal solution, 100 percent close to the ideal solution or not close to the ideal solution.

So this is the criterion which is basically used in TOPSIS to identify exactly how you would determine the best solution. Is closeness to the negative ideal solution analog to a margin of safety which we take? It is a kind of margin of safety we are considering. It is not a margin of safety. It is like trying to measure how close we are to the good thing and how far away we are from the bad thing. It is not a margin of safety really. It is like trying to say that this is the worst thing that could have happened to us and this is the best thing that could possibly have happened to us. Just to measure how close we are to the best and how far away we are from the worst. So you are trying to use that intuitive concept and you are mathematically defining this. The relative closeness ratings for the example that we are just talking about work for instance for the project it works out to 0.643. For the second one, it is point 0.268. For the third one it is 0.613 and for the fourth one it is 0.312 and notice that the closeness rating is a number between 0 and 1 with 0 being the worst possible and one the best possible solution.

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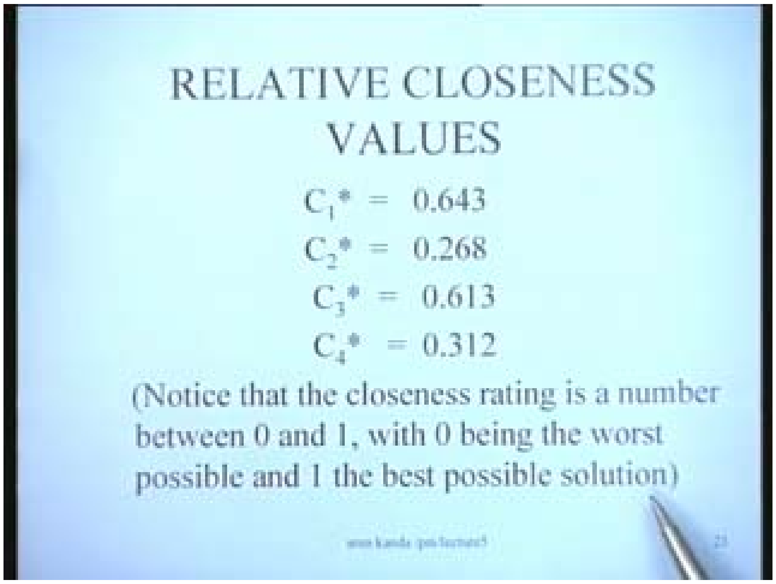

So this can clearly identify that the first project is about 64.3 percent. It meets our aspirations to about 64.3 percent and the second one, third project comes next quite close, 61.3 percent and then of course it is the fourth project and finally the second project. So we can by using this procedure determine a ranking and the ranking can be actually immediately. That is what we had actually wanted to achieve. We are trying to basically rank the project. We are ranking the preference order and the step seven, is determine the preference order by arranging the alternatives in the descending order of C_i star and thus the ranks for alternatives in the fighter aircraft selection problem using TOPSIS emerge as A1, A3, A4 and A2.

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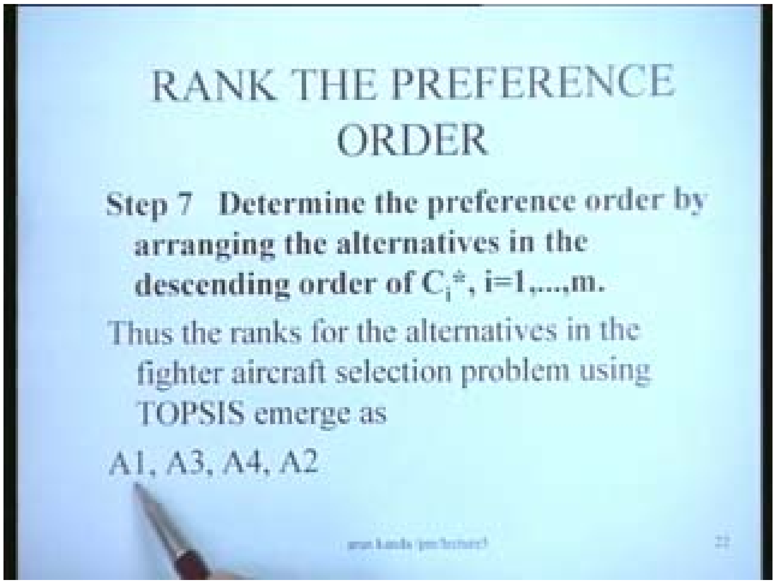

This tells us that for the given weightages which we had, this was our problem. Our problem was how we select a project, given the various appraisal criteria? We have a mechanism using TOPSIS for selecting the projects. Now we can talk about another procedure. Let us talk about another procedure which is, you can say competitor to TOPSIS, called Simple additive weighting procedure, (SAW) procedure. This procedure also requires same information. So, step 1 once again is needed to obtain the decision matrix after converting the intangibles into numbers as we had done earlier.

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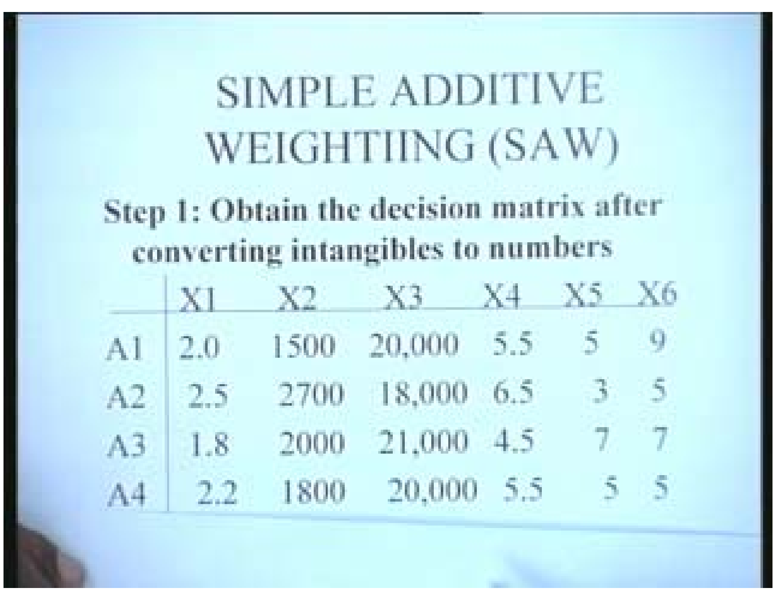

So we have the four options in the same decision matrix. After using the information, it can be utilized here. Then we do the normalization. Normalization in SAW procedure is different. It says we obtain the normalized decision matrix R using this particular relationship. x_{ij} divided by x_j star if the jth criterion is a benefit criterion and this is equal to x_j – divided by x_{ij} if the jth criterion is a cost criterion.

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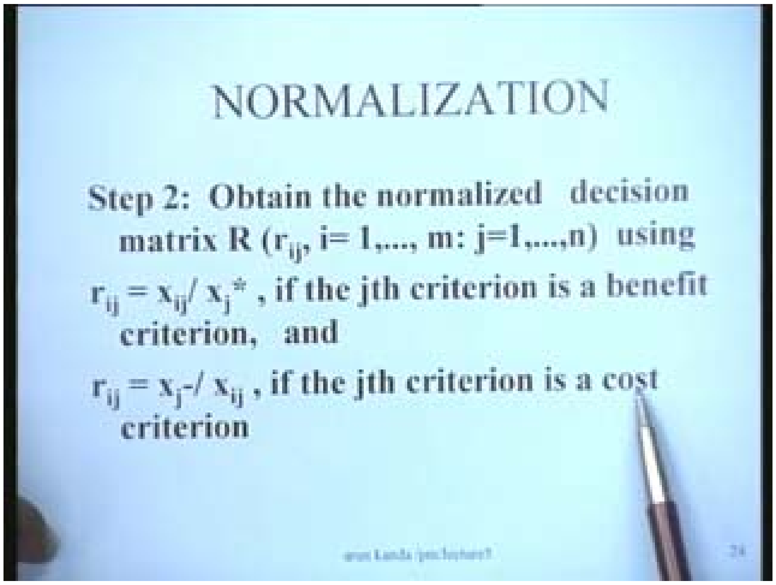

Now patently, this is actually very simple. You look at the decision matrix once again. (Refer Slide Time: 46:03) What we are saying is we are trying to maximize this, obviously this is the best. So what I can do is I can divide everything by 2.5. I can divide everything by 2.5. I can divide everything by 2.5. I would get a number. This is a cost criterion. The least cost is this one. So here instead of dividing by this number, what I can do is I can simply do 4.5 by 5.5, 4.5 by 6.5, 4.5 by 5.5, and 4.5 by 5.5 that means I can take the reciprocal of all these numbers and divide. I mean in that case multiply by 4.5. So this is what the formula essentially is. We can, as a consequence of the normalization, proceed like this. Subsequently we can obtain the final scores through these steps. In step three using the weights for the different criteria, we obtain the weighted score for each alternative using the normalized decision matrix. This we did even in TOPSIS but the difference now is that we are using a different normalization scheme and not only that we are also using a different method of scoring. That is the primary thing. Step four says based on the final scores, these scores are very much like the marks that a set of students would get in different courses and you simply have given different weightages to these courses. You take the aggregate marks and something similar is being done here. So based on the final score we can rate the alternative for a decision by the decision maker.

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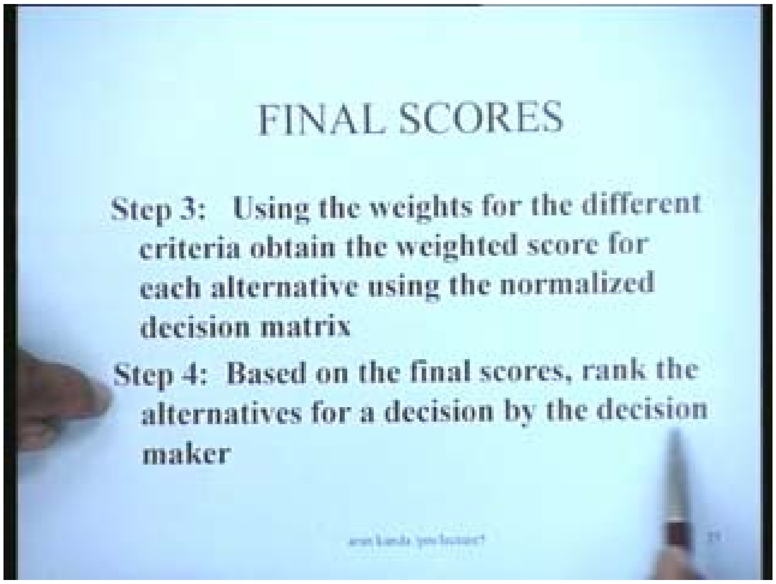

Here the final score is obtained by addition of whole, that score of the alternative in each criterion. The weighted score will be clear from this example. That is how it is obtained. For instance after normalization you got these numbers. You remember wherever the one is, that shows the best possibility and rest is less. So in each column there is a 1 because that is the best option. Then what is being done is that these are the weights, twenty percent weightage to the first criterion, and ten percent to the second and so on. We multiply these weights (with this (Refer Slide Time: 49:30)) and take the score. That means 0.2 into 0.8 + 0.1 into 0.56 + 0.1 into 0.95 + and so on. So that is how the score is obtained. So you can say that these are like the performances of the different candidate projects on different criteria and depending upon the weightages given to the criteria, this is the overall grade point average, the cumulative grade point average in the same sense. So based on this final score, we can determine a ranking of alternatives with SAW and this ranking shows that the rank is A3, A1, A4, and A2.

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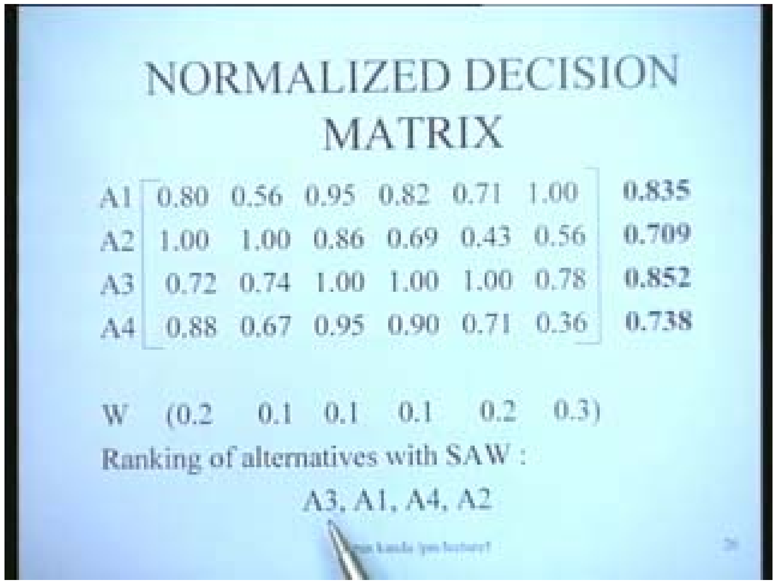

Now you notice that the ranking obtained by different methods need not be the same. In this case let us compare the two. So if we compare SAW and TOPSIS which we have considered, we find that SAW gave a ranking of A3, A1, A4 and A2 whereas TOPSIS gave a ranking of A1, A3 A4, so it is essentially the same except that A1 and A3 have been reversed here in TOPSIS.

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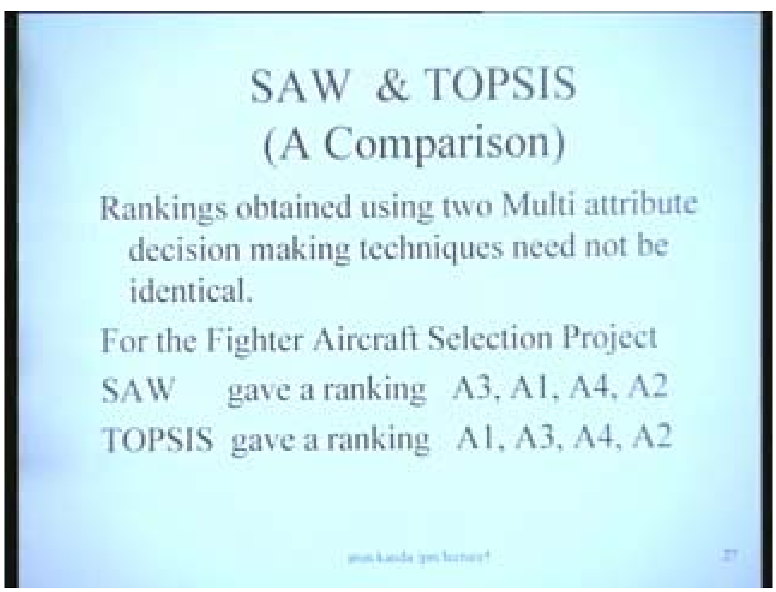

The reason for this is obvious because we have a number and they vary in their normalization pattern and also in the pattern of their scoring. If you give the TOPSIS, we have picked up the best solution and on the basis of the similarity to the ideal solution in this, we had taken weighted average of the scores which had been obtained. So both these things are responsible for different kinds of scores that can be obtained for these situations. Now what we have tried to do in this particular lecture? Let us look at what we have tried to achieve in this particular lecture. We have seen that project selection involves consideration of multiple often conflicting criteria among alternatives. That is why the problem is so complicated. It is not a simple problem and mind you, although there could be easier methods of resolving this problem, when I mentioned to you right in the beginning that when we talked about dominant sets or non dominated solutions, you could look for non dominative solutions. But you could have a cut off point for the performance on each criterion and then use one particular criterion to make a selection. For instance the typical governmental procedure of inviting quotations and then choosing the project with the least quotation shows that you have constructed a feasible set in which the performance on various criterion of all the suppliers is known and ultimately you are using only one criterion to rank the project. That is again one way of solving this particular project but we have seen that project appraisal typically leads to evaluations which may be tangible incommensurate or intangible and we have seen that intangibles are evaluated on a numerical subjective scale typically to get rid of this problem.

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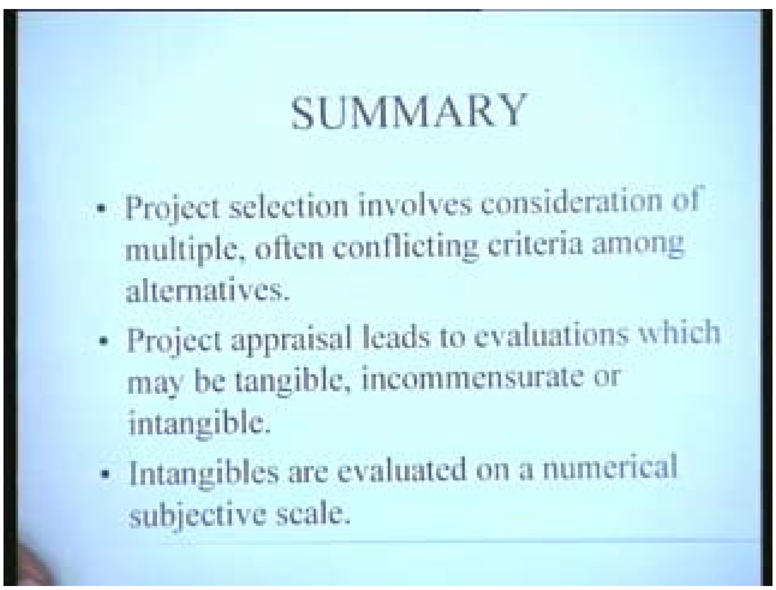

We have also seen that a decision matrix with numerical evaluations is the starting point for multi attribute decision making methods and typically different methods can vary in their normalization schemes and in the manner in which the scoring of alternatives is done. This is important to understand that these are the two major things which characterize a particular method and the fighter aircraft example was illustrated by using both TOPSIS and SAW.

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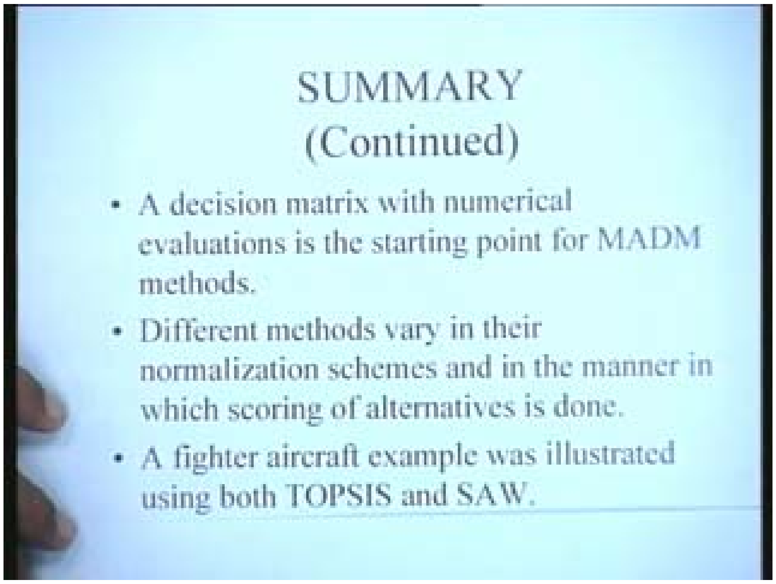

Therefore have seen that this is the manner in which a rational selection of projects after a serious appraisal could be done. We therefore have seen that this is the manner in which a rational selection of projects after a serious appraisal could be done and this brings us to the end of the first phase of the project namely, this is how a project is ultimately chosen and it takes birth. We will subsequently now be talking about the planning and scheduling of projects once the project has taken birth.