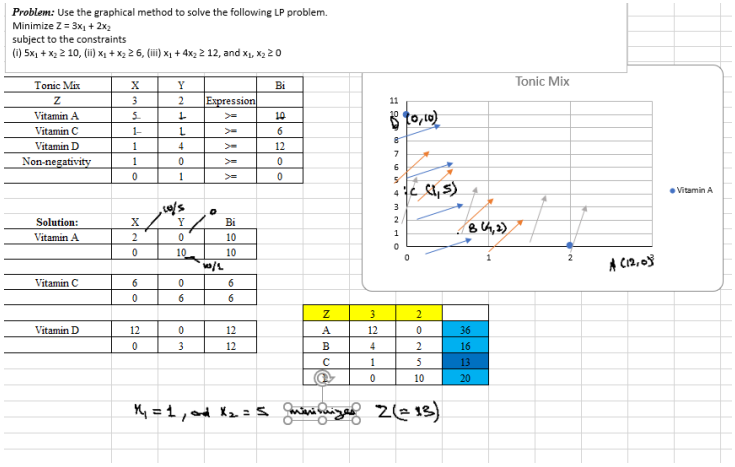
Advanced Business Decision Support Systems
Professor Deepu Philip
Department of Industrial Engineering and Management Engineering
Indian Institute of Technology, Kanpur
Professor Amandeep Singh
Imagineering Laboratory
Dr. Prabal Pratap Singh
Indian Institute of Technology, Kanpur
Lecture 18
Linear Programming Graphical Method, MS Excel Demonstration

Welcome back to the course on Advanced Business Decision Support Systems. We are discussing Deterministic Modeling in this week. I have discussed about the Linear Programming, I have discussed about general Classification of the Modeling and Linear Programming falls into the Deterministic Modeling, where data is certain, where linearity is there, where we try to see that the contributions of each, or the coefficients of each of the variables, that we have taken should be additive. And, contribution per unit for each of the individual variables, that we have taken, should be equal to the sum of the overall contribution that, it is taken. Divisibility is also one of the assumptions. Let us try to see the solution to the Linear Programming problem statements.

A few statements, we have discussed in the last lecture. I will try to now talk about the Graphical Solution to the Linear Programming.



Let us come to the excel demonstration. Now, this is the problem. I have just stated in the MS excel program or MS excel software here. So, this is a minimization problem, where the objective function z is to be minimized, where Z = 3x1 + 2x2 subject to the constraints. Let us take this analogical to the vitamin and tonic problems formulation that

we did in the last lecture. So, there are two tonics x_1 and x_2. There are three kinds of vitamins: vitamin A, vitamin D and may be vitamin C.

So, to solve the problem graphically using MS excel, first we have to jot on the problems or put the problems in the respective cells properly. So, I will try to say, I need to select the tonic mix. So, I have been given may be tonic x and tonic y, which is my x_1 and x_2 and my objective function is to select the tonic x. And, my objective function is said in which, 3 units of x, and 2 units of y are to be maximized. That means, this might be the cost, I am just selecting everything and central lining it.

Now, I have vitamin A, vitamin C and I will just copy it here vitamin D for which, the values are given here, 5 units of x, and 1 unit of y is greater than equal to 10. So, I will put value 5, 1. So, here the functionality or the expression is to be given. I will write it as expression down here, this is greater than equal to 10. So, for vitamin A, for vitamin C it is $1x_1 + 1x_2 \geq 6$ for B2.

Similarly, for vitamin D, it is $1x_1 + 4x_2 \geq 12$ and these 2 constraints are given that is $x_1 \geq 0$. And, $x_2 \geq 0$. These are just in non negativity constraints. This is my problem statement that is given. Now, the steps in plotting the graph were first, we need to convert the constraints into the equality sign.

That means, let me take for each of the constraints separately, I will write here the solution and I will bold it for vitamin A, then I will also take it for vitamin C and vitamin D here. This is vitamin C, this is for vitamin D. For vitamin A, the value that is given on the right hand side is 10. So, I will put this value, the right hand side value here. So, I will say, the value of x, value of y and I would say Bi.

Let me first put the value of Bi here for vitamin in the 2 rows because I need to have the coordinates while putting value of x1 0 and then value of x2 0. For this, I will have to have 2 equations. So, this is for vitamin A, this is for vitamin C and third one is for vitamin D, these values are given here. If I put my value of y here as 0, my x becomes, from this equation, I am looking at for vitamin A, so, my x becomes, x equal to the Bi value 10 divided by the coefficient of the x that is, 2 and if I put my value of x1 here as 0 in this cell B17. I have put value 0 my y becomes that is, the value of tonic y = Bi.

So, you should be clear. So, this is 0 and this is 10 by 5, this 10 divided by this 5 for the value of x_2. This is 10 by 1, that is 10 divided by this 1. Now, similarly for vitamin C we can calculate the values are 1,1.

So, it would be directly will have 6 0 and 0 6 because the coefficients are 1 1 here. So, 6 divided by 1 would be always 6, then for vitamin C, we have 1, 4, 12. So, if I put this as 0 for y for x = 12 that is cell E10 divided by the cell B10 this value is 12, and if I put this as 0, this is taken from the formula of simple divisibility that is E10 divided by C10.

Now, I have got all the coordinate values that is 2, 0. 0,10 is my first constraint coordinates 6, 0, 0, 6 my second constraint coordinates and for vitamin E that is the third constraint is 12, 0 and 0, 3.

Now, these coordinates are to be plotted. To simply plot it, I can just pick the coordinates and try to insert a scatter plot. So, how do I do? I just select these cells, x and y for vitamin A only and I go to the insert tab. In the insert tab I could see certain ribbons here, tables, illustrations, add-ins charts, sparklines, filters, links, comments, text, symbols or so. So, in the charts there are certain charts available.

That, this is a dotted chart here, I will try to just click here, I find this scatter chart here. The scatter chart could have just these scatter points here. Scatter points with line or the lines without scatter points and so on certain ways are there to plot. I will just pick one kind. So, this is my line that is plotted.

Similarly, I can plot the other lines. Now, to insert the vitamin C and vitamin D lines in this chart only, I need to select this chart only. Suppose, if I try to plot vitamin C here, and try to insert the chart, it will insert a separate chart here. You can see now we have two separate charts. The left one is for vitamin C, the right one is for vitamin A.

So, I am just deleting the vitamin C chart I will select the chart here only, the chart title here is tonic mix and I will select the chart I will right click on the chart, then I say select data. Select data, I got the information about the data based upon which this chart is plotted. So, I can edit this. So, series name could also be put for the line that is already drafted or drawn on the chart. Series name is I select this cell, A 16 that is vitamin A, I say okay, series name is given vitamin A.

Now, I can also add further series here. I select the series name as vitamin C. I select the value of x as I can upload the value of x is 6 and 0. Then I select the value of y as this 0 and 6 I say ok, you can see vitamin C line is also plotted here. Similarly, I can add another series, whose name is vitamin D taken from this cell.

I add the value of x here, that is these two cells 12 and 0. Then, I add the values of y here that is 0 and 3 and the three lines are plotted here I say ok. Now, these charts are complete or plotted. Now, I need to label them further and try to have the feasible solution out of them. You can see, I can definitely add labels here, I can add legend here.

To add the legend, I just click on the chart, when I click on the chart, there are certain ribbons which are here, add chart element, quick layout. If I go the quick layout there are certain options available. See, it has the chart title, legend at is given on the right, horizontal axis title, vertical axis title everything is given. So, there is another layout

available. Third layout is like where the grid lines are also there, there is a layout where even the horizontal grid lines are not even available.

So, the certain layouts available I just need to add the legend or you can just go to the chart element and say ok, legend is required at the right. Now, this is given here which is the area that I need to shade that is important point here because we need to look at the expressions or the inequality signs. All the inequalities expressions which are given here are greater than or equal to, which means area away from origin would be taken as our feasible shaded area or feasible solution, which means, just to show it, I will just insert arrows here in the insert tab, when I go, there are options to insert shapes. You can see in the illustrations, I go to shapes here. So, I just insert an arrow here towards the direction away from 0.

I will just copy and paste this arrow 3 or 4 times and try to say, this is for vitamin A. We are going away from the origin and the feasible region towards this direction and I will also try to paste it once more and then, I can change the color or right click over it and I go to the outline color and pick the color, which is similar to the color of the vitamin C taken by this graph and I draw a line perpendicular to it. So, we go towards this direction control C and V. When I control C and V if I do that is, I copy and paste the arrows, it would not change the angle. So, towards the open area away from origin, I am plotting because the expression is greater than equal to, let me try to paste it once more, it has come here.

So, here, I need to change the color once again to grey then, I say, this is also away from region which means, I get the solution points here. This is point number 1, I call it as point A. This is another point, I call it as point B. You can also find a intersection points in the scatter plot, this is point number C and this is point number D. So, for all the points, we can see what are the values, this is very clear, this value here x is 12 and y is 0, this value we can very clearly see, it is $4x_1$ and $2x_2$, C is not clear.

So, see the value of C in a graphical solution, we can further have grid lines or we can may be dense. So, way to find the value or the coordinates of C, we can even have the denser grid lines one. So, let me have a chart with a grid lines here. So, here you can see, we can see the values are there going close to 3 or so, but still if this does not work, I will undo it control Z, I will have my denser axis. So, I go to the axis, select axis here, any of the axis.

I right click here and I say format axis. To format axis, you can see on the right hand side units major 2, minor 0.4. Those are given minimum value 0 and 12, I can just turn this major value to 1. Let me say, if it helps me for this value again.

The value of C yes, this value of intersection is here. So, it is 5, you can see this is 5. Let me also make this axis denser, it is the x axis, I will say format axis. So, I will have grid line at each one unit Now, we have the exact point.

Here this point is C, which is 1 and 5. Now, the point D that is, one of the solutions is 0 and 10 where actually visible. Now, we can put down these values and try to get the solution graphically, we have got 4 values here, that is feasible solutions or 4 extreme point solutions here, A, B, C and D and I put my objective function here that is Z central line everything. So, objective function coefficients here are 3 and 2 and the coordinates that we have gotten from A, B, C, D are given here.

The coordinates for A are 12 and 0 for the extreme solution or extreme point solution, B is 4 and 2, for the C, it is 1 and 5, for the D point, it is 0 and 10. Simply to calculate the value which is a minimization problem for the Z, I say for the solution A = 3 times of the cell G 2022 into 12 + 2 times into the cell H22, Enter.

So, this value is 36 is my solution. I can calculate them individually while putting this formula like for example, I put the formula for this once again, this = 3 times the coordinate here 4 + 2 times into this value = 16 or I can simply lock the value of this cell that is G21 and H21. I am completely locking it because this value is unchangeable to lock it. I put dollar signs before the letter and the number, enter. And, I just drag the formula down, I get these values. So, the minimum value that is gotten for the graph that we have plotted is 13.

So, this is the minimum value, I just talk about it. So, that means, the solution here is for the value of X_1 that is, tonic X_1 unit and $X_2 = 5$ unit minimizes Z = 13. This is solution using the Microsoft Excel. So, though you might have understood the problem statement and how do we have formulated that, problem statement was already there.

That was given in the excel sheet here. So, this is the graphical solution of the Linear Programming problems. So, there has to be two variables only where we need to plot the graph. These two variables could be the overall constraint, that is given or when we try to select the two basic variables, could also be solved using the graphical method. So, this covers the graphical method, we will try to see for the larger problems or maybe the more realistic problems when we have bigger constraints and more variables which are to be catered to. We need to have a little sophisticated method for that simplex method.

So, that is very common to solve the Linear Programming statements and we will try to see the simplex method to solve the linear programming in the next lecture. Thank you.