MS Excel

Topics - Solver, Linear Programming Problems.

Linear Programming Problems

One of the tools offered by MS Excel is solver which helps in solving linear programming problems i.e. solving the constrained optimization problems.

A typical constrained optimization problem involves an objective function which is available in the form of a liner combination of involved variables. The goal of the problem is to find those values of the involved variables at which the object function either takes its optimum value (maximum or minimum) subject to a list of constraints. A linear programming problem can be written as follows:

Optimize

$$Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$$

Subject to the constraints:

$$a_{11}x1 + a_{12}x2 + \ldots + a_{1n}x_n <= \text{or} = \text{or} >= b_1$$
$$a_{21}x1 + a_{22}x2 + \ldots + a_{2n}x_n <= \text{or} = \text{or} >= b_2$$
$$\ldots$$
$$a_{m1}x1 + a_{m2}x2 + \ldots + a_{mn}x_n <= \text{or} = \text{or} >= b_m$$
$$x_1, x_2, .., x_n >= 0$$

In manually, the solution of linear programming is obtained by using graphical method or simplex method. The method may result into successful discovery of values of variables that satisfy the given LPP problem if the solution is feasible. Otherwise the method results into cases where either no solution exists, or more than one solutions exist or the solutions are degenerative. Simplex is a lengthy process. However, the solver tool can quickly solve an LPP problem.

Solving LPP using Excel

One should follow the following steps to solve an LPP.

Step 1: Enable Solver if not already enabled.
Step 2: Identify the cells that represent the input variables.
Step 3: Enter the formula of the objective function in some cell
Step 4: Enter the LHS and RHS for each of the constraints
Step 5: Start Solver
Step 6: Select the goal of the objective function to maximize, minimize or take the function's value to some fixed value
Step 7: Provide the address of the input cells
Step 8: Add each constraint one by one by specifying the cell references for the LHS part, RHS part and the type of constraint.
Step 9: Select the solving method as Simplex LP solution is to be found using Simplex method. Otherwise a user can also select the method of GRG engine which computes a nonlinear local optimal solution for non-convex problems.
Step 10: Select Solve

If the solver finds a solution, it puts the computed values for the input variables in the cells designated for them and shows a screen that tells that it has found a solution. It can further asks if user also want to generate additional reports for Answer, Sensitivity and Limits.

Understanding additional reports

If solver is able to find an optimum solution of an LPP, it can provide three reports namely answer, sensitivity and limit reports. However if solver does not find a solution, it provides a feasibility report indicating the constraints that make the solution infeasible. And if there is no converging solution for an LPP, solver only informs that solution is non convergent, but it does not give any report in that case.

Answer Report

Answer Report provides the result of the solver. The report also the optimum value achieved by the objective function and the values of the variables at which the optimum value of the objective function is achieved. However, these values are also available in the corresponding cells on the excel sheet. It also suggests if any constraint has been exhausted completely or not. If not it shows that the constraint is not binding and shows the value of slack variable.

Microsoft Excel 15.0 Answer Report
Worksheet: [Case1.xlsx]Q1
Report Created: 16-02-2017 12:25:39
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine
Solver Options

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$I$7	Coefficients --> Formula	1000	1000

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$F$3	Var Values (to be found) --> x1	18	18	Contin
$G$3	Var Values (to be found) --> x2	8	8	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$I$11	Constraint 1 --> Constrint LHS	60	$I$11<=$K$11	Binding	0
$I$12	Constraint 2 --> Constrint LHS	96	$I$12<=$K$12	Binding	0
$I$13	Constraint 3 --> Constrint LHS	18	$I$13>=$K$13	Binding	0
$I$14	Constraint 4 --> Constrint LHS	8	$I$14>=$K$14	Not Binding	8

Sensitivity Report

The sensitivity report suggest as to how much change in the variables or constraint limits can be made so that the input variables required to achieve the objective function still remains same.

Microsoft Excel 15.0 Sensitivity Report
Worksheet: [Case1.xlsx]Q1
Report Created: 16-02-2017 12:25:39

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$F$3	Var Values (to be found) --> x1	18	0	40	6.666666667	16.66666667
$G$3	Var Values (to be found) --> x2	8	0	35	25	5

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$I$11	Constraint 1 --> Constrint LHS	60	3.333333333	60	36	12
$I$12	Constraint 2 --> Constrint LHS	96	8.333333333	96	24	36
$I$13	Constraint 3 --> Constrint LHS	18	0	0	0	1E+30
$I$14	Constraint 4 --> Constrint LHS	8	0	0	8	1E+30

Limits Report

The report shows the value of objective function at the lower and upper limits of the input variables.

Microsoft Excel 15.0 Limits Report
Worksheet: [Case1.xlsx]Q1
Report Created: 16-02-2017 12:25:39

		Objective
Cell	Name	Value
$I$7	Coefficients --> Formula	1000

		Variable		Lower	Objective	Upper	Objective
Cell	Name	Value		Limit	Result	Limit	Result
$F$3	Var Values (to be found) --> x1	18		0	280	18	1000
$G$3	Var Values (to be found) --> x2	8		0	720	8	1000

Feasibility Report (In fact infeasibility report)

This report is generated when the solver is not able to find a solution. The report mentions the constraints which make the problem infeasible.

Microsoft Excel 15.0 Feasibility Report
Worksheet: [Case3.xlsx]Q
Report Created: 16-02-2017 12:36:51

Constraints (not including Variable Bounds) Which Make the Problem Infeasible

Cell	Name	Cell Value	Formula	Status	Slack
$I$12	Constraint 2 --> Constrint LHS	15	$I$12>=$K$12	Violated	-20
$I$15	Constraint 5 --> Constrint LHS	3	$I$15=$K$15	Binding	0

Graphically representing the feasible region of an LPP

A user can graphically represent the feasible region of an LPP by plotting each equation on a scatter plot. Use the following procedure for this purpose:

Step 1: Convert each equation into an equality relationship
Step 2: Find the coordinates on the line when x is zero and when y is zero.
Step 3: Prepare x-axis point for the scatter graph
Step 4: Plot each line as a separate series
Step 5: Identify the area represented by each line by using the inequality
Step 6: Insert an scribbled area for the common feasible region.