Ekonomická fakulta
Faculty of Economics

Jihočeská univerzita v Českých Budějovicích
University of South Bohemia in České Budějovice

Linear Optimization with Solver

Jana Klicnarová

Faculty of Economics, University of South Bohemia

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education

MINISTRY OF EDUCATION,
YOUTH AND SPORTS

Prototype Example

The Best Glass CO. plan to use the remaining time of their production lines to start with the production of two new types of windows – let us call them Windows 1 and Window 2. All of these windows must go through three production lines, where the capacities of the lines are $60,\ 60,\ 85$ hours. The unit of the first window type needs 2 hours at the first production line, 6 at the second one and 10 hours at the last production line. The unit of Windows 2 needs 10 hours at the first production line, 6 at the second one and 5 hours at the last production line.
The marketing division considers that the company could sell as much of either product as could be produced and it is supposed that the profit from each unit of Windows 1 would be 30 thousand dollars and from each unit of Windows 2 45.
It is not clear which mix of these two products would be most profitable.

Prototype Example – Mathematical Model

$$
\begin{aligned}
& \max 30x_1 + 45x_2 \\
\text{subject to } & 2x_1 + 10x_2 \leq 60, \\
& 6x_1 + 6x_2 \leq 60, \\
& 10x_1 + 5x_2 \leq 85, \\
& x_1,\ x_2 \geq 0.
\end{aligned}
$$

First, we need to prepare the data in the Excel sheet. In the first step we rewrite the data of our example in the following way.

	windows 1	windows 2				capacity
line 1	2	10				60
line 2	6	6				60
line 3	10	5				85
profit	30	45				

Now, we need to add variables. In our prototype example, we have two variables; hence we need to cells for them – we choose two cells and set them to be variables. We put the starting points into them – 0s.

	windows 1	windows 2				capacity
line 1	2	10				60
line 2	6	6				60
line 3	10	5				85
profit	30	45				
variables	0	0				

Then, we need to prepare all the functions which we use in the model – objective function and all left-hand sides of the constraints.

	windows 1	windows 2	used capacity			capacity
line 1	2	10		`=SUMPRODUCT(B2:C2;$B$8:$C$8)		
line 2	6	6		`=SUMPRODUCTÍ(B3:C3;$B$8:$C$8)		
line 3	10	5		`=SUMPRODUCT(B4:C4;$B$8:$C$8)		
profit	30	45		`=SUMPRODUCT(B6:C6;$B$8:$C$8)		
variables	5	5				

Solver

	A	B	C	D	E	F	G
1		windows 1	windows 2		used capacity		capacity
2	line 1	2	10		60		60
3	line 2	6	6		60		60
4	line 3	10	5		75		85
5							
6	profit	30	45		375		
7							
8	variables	5	5				

Solver Parameters

Set Objective: $E$6

To: Max Min Value Of: 0

By Changing Variable Cells: $B$8:$C$8

Subject to the Constraints:

$E$2:$E$4 <= $G$2:$G$4

Add
Change
Delete
Reset All
Load/Save

Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP

Options

Solving Method

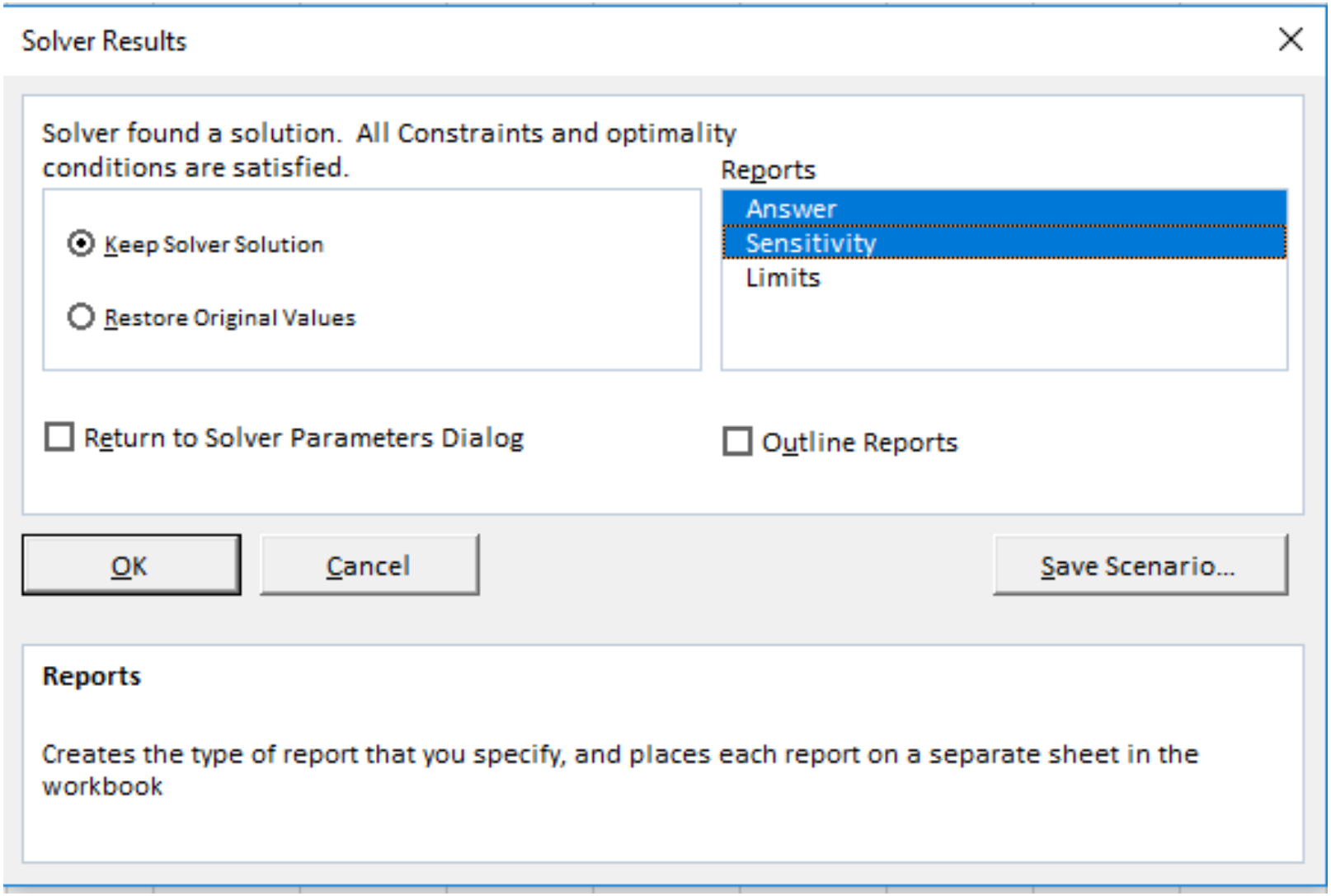
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Help Solve Close

Solver – Results

To possible ends of the Solver are:

- Solver found an optimal solution,
- Solver did not find an optimal solution.


Solver Results
Solver found a solution. All Constraints and optimality conditions are satisfied.
Keep Solver Solution
Restore Original Values
Reports
Answer
Sensitivity
Limits
Return to Solver Parameters Dialog
Outline Reports
OK
Cancel
Save Scenario...
Reports
Creates the type of report that you specify, and places each report on a separate sheet in the workbook

Post-optimisation Analysis

Questions as

- what does happen if the DM decides to produce a non-optimum product,
- in which price is advantageous to buy more supplies,
- in which price is advantageous to sell a part of supplies,
- if the profit of some product will be changed, will it change the result,
- and so on,

can be often answered without any new optimisation.

Answer Report

Microsoft Excel 16.0 Answer Report
Worksheet: [lp.xlsx]Example
Report Created: 3/6/2019 10:05:59 AM
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine
Engine: Simplex LP
Solution Time: 0.031 Seconds.
Iterations: 2 Subproblems: 0
Solver Options
Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$E$6	profit used capacity	375	375

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$8	variables windows 1	5	5	Contin
$C$8	variables windows 2	5	5	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$E$2	line 1 used capacity	60	$E$2<=$G$2	Binding	0
$E$3	line 2 used capacity	60	$E$3<=$G$3	Binding	0
$E$4	line 3 used capacity	75	$E$4<=$G$4	Not Binding	10

Sensitivity Report

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [lp.xlsx]Example
Report Created: 3/6/2019 10:05:59 AM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$8	variables windows 1	5	0	30	15	21
$C$8	variables windows 2	5	0	45	105	15

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$E$2	line 1 used capacity	60	1.875	60	40	16
$E$3	line 2 used capacity	60	4.375	60	5.333333333	24
$E$4	line 3 used capacity	75	0	85	1E+30	10