

# Appendix 5

## Using OpenSolver

In this Appendix, we introduce the user interface for OpenSolver and discuss some of the differences between OpenSolver and Excel's Solver.

### 1. BACKGROUND

OpenSolver is an add-in that extends Excel's Solver with a more powerful linear solver suitable for handling linear programming and mixed integer programming models. (Nonlinear programming capability has been added more recently.) OpenSolver provides the following features:

- OpenSolver uses the Open Source, COIN-OR CBC (linear) optimization engine.
- It is compatible with spreadsheet models built with Excel's Solver.
- It has no artificial limits on problem size.
- It is free, open source software licensed under the CPL.
- Recent versions also offer NOMAD, a nonlinear optimization engine.

In addition to providing an alternative optimization engine, OpenSolver offers:

- a built-in model visualizer that highlights the model's decision variables, objective and constraints directly on the spreadsheet
- a QuickSolve mode for fast re-solving after making right-hand side changes
- an Auto Model feature that analyses the spreadsheet layout and then fills in the Solver dialog automatically.

OpenSolver has been developed for Excel 2007, 2010, and 2013 versions running on Windows. It should work with these or later Excel versions.

### 2. INSTALLING OPENSOLVER

Here are the steps for downloading OpenSolver

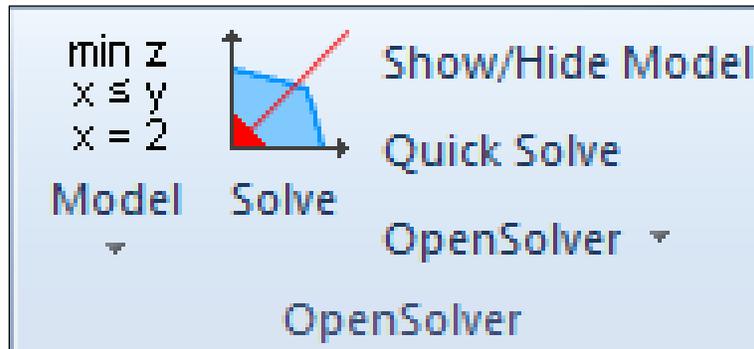
- Download the OpenSolver.zip file from the main website [www.opensolver.org/](http://www.opensolver.org/)
- Extract the files to a convenient location
- Double click on OpenSolver.xlam
- If asked, give Excel permissions to run OpenSolver

The OpenSolver commands will then appear under Excel's Data tab.

OpenSolver will be available until Excel is closed. To make OpenSolver available whenever Excel opens, the files from the OpenSolver.zip folder must all be copied into the Excel add-in directory, typically: C:\Documents and Settings\"user name"\Application Data\Microsoft\Addins\

### 3. THE OPENSOLVER INTERFACE

The OpenSolver commands appear on Excel's Data tab, as shown in Figure A6.1. This addition to the ribbon becomes visible after double-clicking on OpenSolver.xlam.



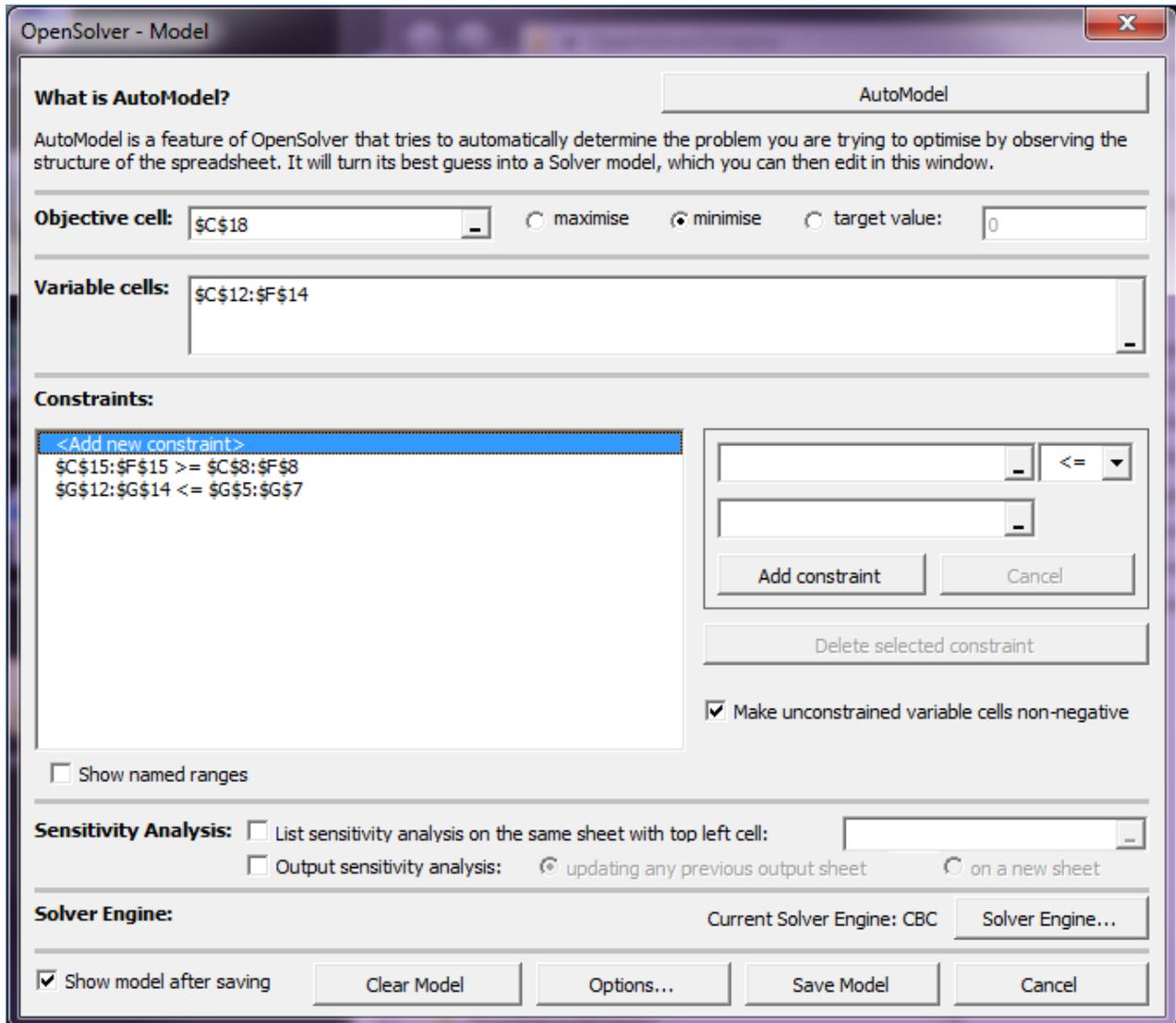
**Figure A6.1.** The OpenSolver group on the Data tab

For our purposes, we assume that the model has been built using Excel's Solver, with the objective function, variables, and constraints specified. Once the model is built, the Show/Hide Model button enables the model to be checked. As shown for the example model in Figure A6.2, this option adds some highlighting, labels the objective function *min* or *max*, and shows the correspondence between left-hand and right-hand sides of the constraints.

	A	B	C	D	E	F	G
1	<b>Network: Transportation Problem</b>						
2							
3	<b>Parameters</b>						
4			Atl	Bos	Chi	Den	Capacity
5		Minn	0.60	0.56	0.22	0.40	10,000
6		Pitt	0.36	0.30	0.28	0.58	15,000
7		Tucs	0.65	0.68	0.55	0.42	15,000
8		Requirement	8,000	10,000	12,000	9,000	
9							
10	<b>Decisions</b>						
11			Atl	Bos	Chi	Den	Sent
12		Minn	0	0	10000	0	10,000
13		Pitt	5000	10000	0	0	≥ 15,000
14		Tucs	3000	0	2000	9000	14,000
15		Received	≤ 8,000	10,000	12,000	9,000	39,000
16							
17	<b>Objective</b>						
18		Total Cost	min	13,830			
19							

**Figure A6.2.** Result of the Show/Hide option for the example in Figure 3.2

Clicking on the button in the upper left-hand corner around min z) brings up the Model window (Figure A6.3). This window contains sections for the objective cell, variable cells, and constraints, which reproduce the specification in Excel's Solver. Also visible is a check box for declaring all variables to be non-negative. These sections can also be used to edit the model or rebuild it from scratch.



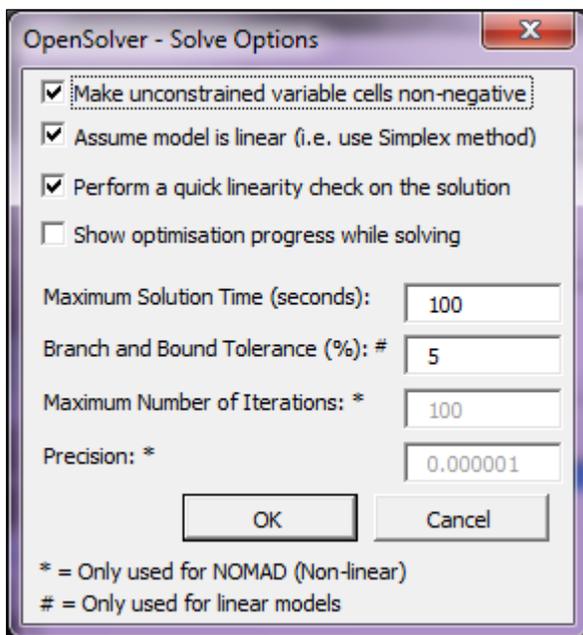
**Figure A6.3.** Model window for the example

Below the specifications is the Sensitivity Analysis section, to be covered later, and the Solver Engine section, where selecting the Solver Engine... button opens the window shown in Figure A6.4. Here, the drop-down menu lists several possible engines, which may not all be available. As stated in the window, the COIN-OR CBC Engine is the default choice. It is suitable for linear and mixed integer programming models. The NOMAD Engine is available for nonlinear models.



**Figure A6.4.** Engine selection window

Along the bottom of the Model window are a check box and several buttons. The Options... button opens the window shown in Figure A6.5, where the first three check boxes are normally selected for linear models.



**Figure A6.5.** Options window

To solve the model, click the Solve button on the ribbon. OpenSolver analyses the spreadsheet to extract the optimization model, which is then written to a file and passed (over the Internet) to

the CBC engine to solve. The result is automatically loaded back into the spreadsheet. A dialog is shown only if errors occur.

After solving, OpenSolver does a quick check for linearity in the sense that the objective and constraints behave as expected when the optimal solution is loaded into the sheet. If not, OpenSolver shows an alert, and can then do a detailed linearity analysis.

To perform a sensitivity analysis, select one of the check boxes in the Sensitivity Analysis section of the Model window, as shown in Figure A6.6. In this case, the option has been selected to place the output on a new sheet, and when the model is solved, a worksheet is added with the information shown in Figure A6.7. The display has been slightly reformatted. (When the option to use the same sheet is selected, the summary is abbreviated.)

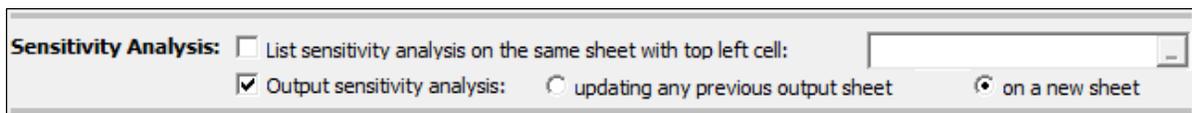


Figure A6.6. Selections for sensitivity analysis

Open Solver Sensitivity Report - CBC							
Decision Variables							
Cells	Name	Final Value	Reduced Costs	Objective Value	Allowable Increase	Allowable Decrease	
C12	Minn Atl	0	0.28	0.60	#####	0.28	
D12	Minn Bos	0	0.30	0.56	#####	0.30	
E12	Minn Chi	10000	0.00	0.22	0.28	#####	
F12	Minn Den	0	0.31	0.40	#####	0.31	
C13	Pitt Atl	5000	0.00	0.36	0.02	0.09	
D13	Pitt Bos	10000	0.00	0.30	0.09	0.59	
E13	Pitt Chi	0	0.02	0.28	#####	0.02	
F13	Pitt Den	0	0.45	0.58	#####	0.45	
C14	Tucs Atl	3000	0.00	0.65	0.09	0.02	
D14	Tucs Bos	0	0.09	0.68	#####	0.09	
E14	Tucs Chi	2000	0.00	0.55	0.02	0.28	
F14	Tucs Den	9000	0.00	0.42	0.31	0.42	
Constraints							
Cells	Name	Final Value	Shadow Price	RHS Value	Allowable Increase	Allowable Decrease	
C15>=C8	Received Atl	8000	0.65	8000	1000	3000	
D15>=D8	Received Bos	10000	0.59	10000	1000	3000	
E15>=E8	Received Chi	12000	0.55	12000	1000	2000	
F15>=F8	Received Den	9000	0.42	9000	1000	9000	
G12<=G5	Minn Sent	10000	-0.33	10000	2000	1000	
G13<=G6	Pitt Sent	15000	-0.29	15000	3000	1000	
G14<=G7	Tucs Sent	14000	0.00	15000	#####	1000	

Figure A6.7. Sensitivity analysis result for the example model when output to a new sheet

#### **4. ADDITIONAL INFORMATION**

OpenSolver was developed by Andrew Mason in the Department of Engineering Science at the University of Auckland. Visit [www.opensolver.org](http://www.opensolver.org) for more information.

OpenSolver uses the open source COIN-OR CBC optimization engine. CBC is released as open source code under the Common Public License (CPL). It is available from the COIN-OR initiative ([www.coin-or.org/projects/Cbc.xml](http://www.coin-or.org/projects/Cbc.xml)). The CBC code has been written primarily by John J. Forrest and is maintained by Ted Ralphs.

Please see the included license files for more details and the ChangeLog file for more details of recent improvements.