Research Seminar 1.
Using Solver

- Whats and Whys of Solver
- Setting Up a Linear Program
- Sensitivity Analysis of Linear Programs

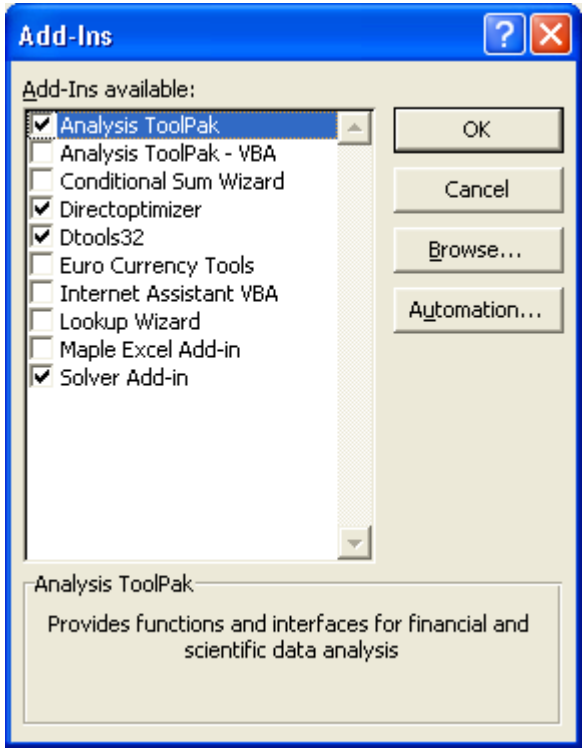
What is Solver

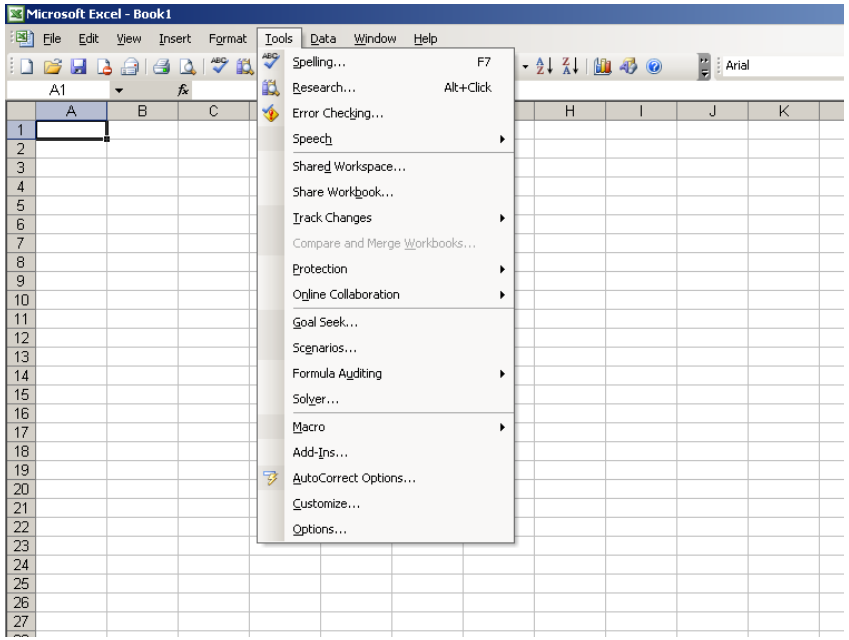
- Solver is an optimization add-in available in Excel
- Available in standard installs of Excel
- Optimization problems involving maximizing the use of scarce resources, or minimizing the wastage of resources
- There are linear and non-linear, continuous and discrete versions of optimization
- We'll talk more about linear programming, which may be solved using the simplex algorithm on computers

Why Use Solver

- You might find Solver useful in your professional lives and also for this course
- Solving linear systems of equations
- Displaying games and data
- Solving some game theory problems
- Note: there are other scientific computing packages in this space (including Matlab and Maple, GAMS)

Loading Solver





Screenshots by Scott Cunningham, using Microsoft Excel Solver.

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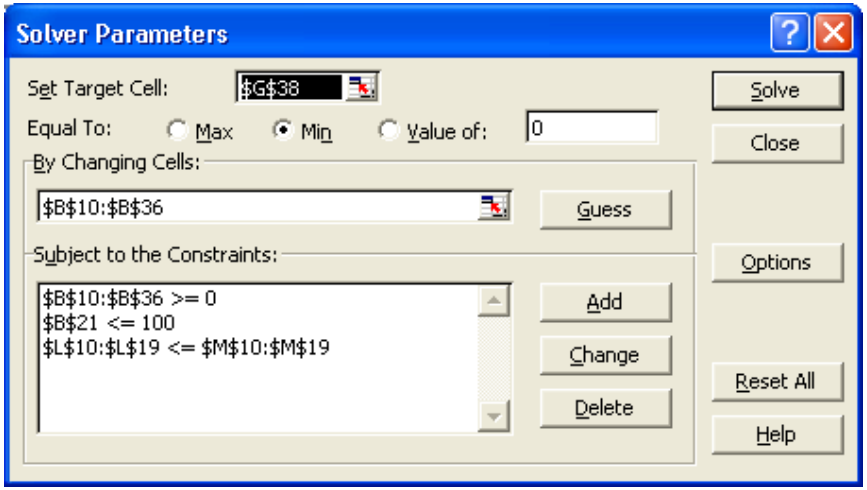
The Main Solver Window



- Spreadsheet contains the data and parameters for the model
- Solver window contains the linear program
- The parts are
  - Objective function
  - Decision variables
  - Constraints

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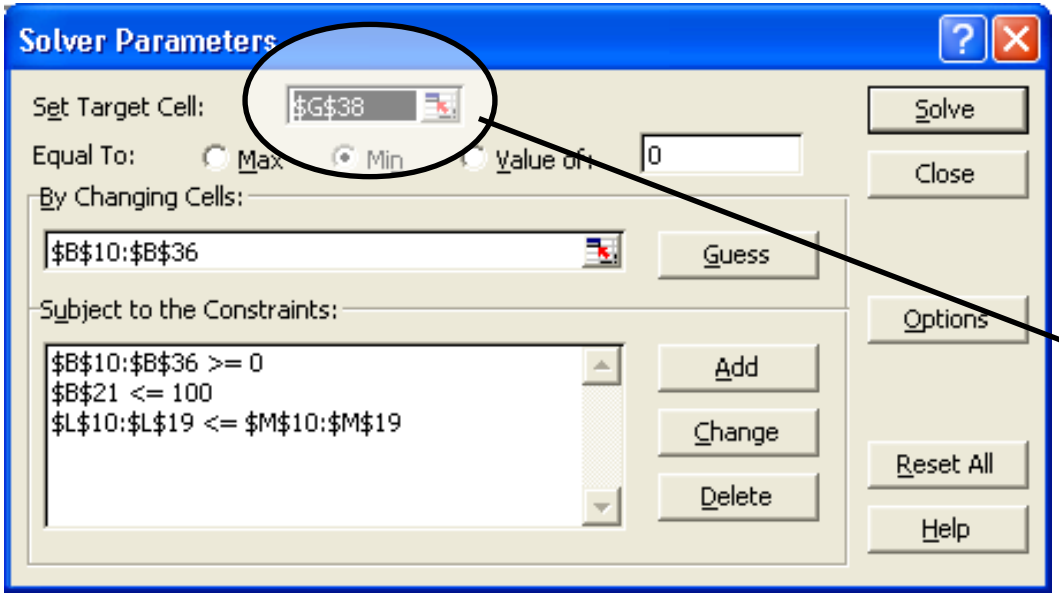
Entering the Objective in Solver



Enter the objective here, a single c
containing a formula, from the
spreadsheet. This should be the
output of the system represented i
Excel.

Screenshots by Scott Cunningham, using Microsoft Excel Solver.

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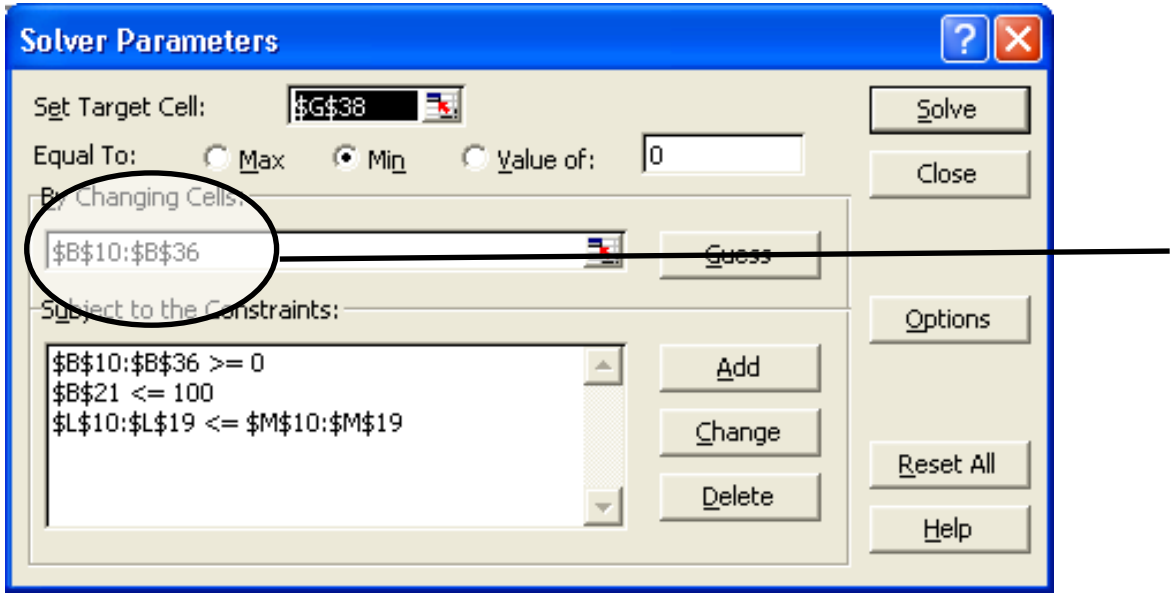
Entering the Decision Variables in Solver



Enter the decision variables here, usually a range of cells in the spreadsheet. This range should affect the system model, through the appropriate use of formulas in Excel.

Screenshots by Scott Cunningham, using Microsoft Excel Solver.

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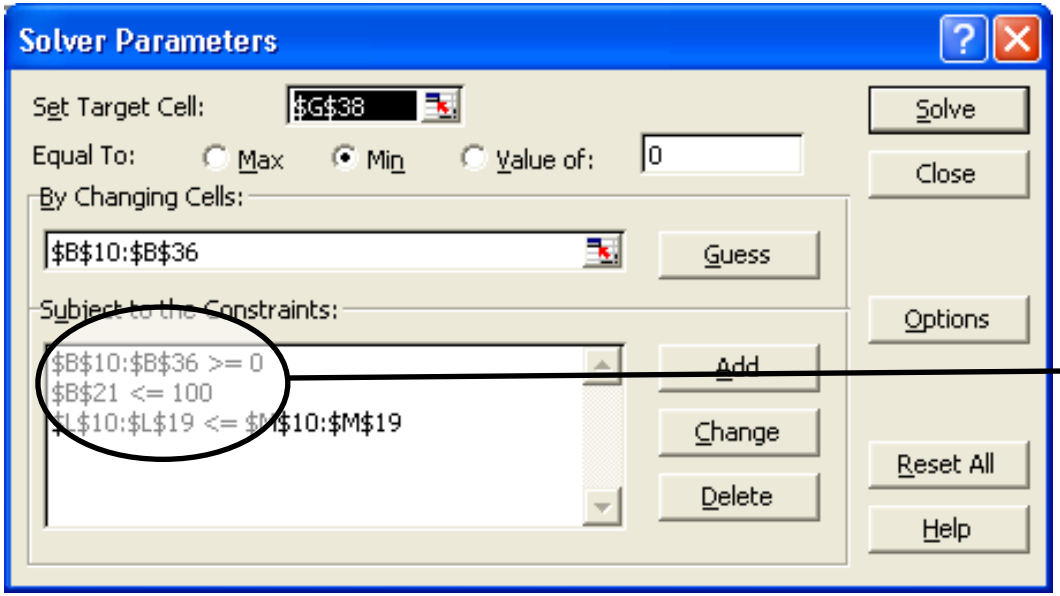
Entering the Constraints in Solver



Enter the constraints here. Use ranges when appropriate! You can also use ranges as right hand sides, consistent with good spreadsheet design.

This range should affect the system model, through the appropriate use of formulas in Excel.

Screenshots by Scott Cunningham, using Microsoft Excel Solver.

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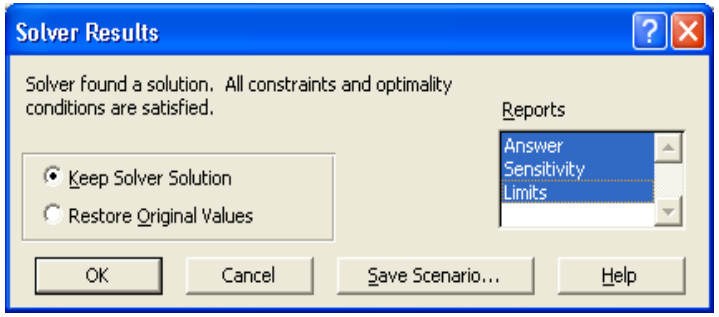
Solver Results Window



- After running Solver you'll get the Results window
- You can keep the solution or restore the decision variables to how they were before analysis
- You'll need to use the chooser to find the three available reports
  - Answer, Sensitivity, Limits

Screenshots by Scott Cunningham, using Microsoft Excel Solver.

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Sensitivity Analysis and the Simplex Algorithm

- Because it is linear, more sensitivity analysis
  - Range of values the objective function can assume without changing the optimal solution
  - Impact on optimality as we tighten constraints
  - Impact on optimality as we force decision variables away from their optimum
  - Impact that changes in constraint coefficients will have on the optimal solution

The Answer Report

Summary of the solution, and which constraints actually limited the solution

Target Cell (Min)

Cell	Name	Original Value	Final Value
$G$4	Unit Cost Total Costs	7	7

Adjustable Cells

Cell	Name	Original Value	Final Value
$C$3	Quantities to Generate No Cooling Tower	0.388888889	0.388888889
$D$3	Quantities to Generate Cooling Tower	0.722222222	0.722222222
$E$3	Quantities to Generate Import	0.888888889	0.888888889

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$G$8	Thermal Standards Generated	5	$G$8<=$H$8	Binding	0
$G$9	Generation Limits 1 Generated	0.388888889	$G$9<=$H$9	Not Binding	2.611111111
$G$10	Generation Limits 2 Generated	0.722222222	$G$10<=$H$10	Not Binding	1.277777778
$G$11	Generation Limits 3 Generated	0.888888889	$G$11<=$H$11	Not Binding	0.111111111
$G$7	Energy Demand Generated	2	$G$7>=$H$7	Binding	0
$C$3	Quantities to Generate No Cooling Tower	0.388888889	$C$3>=0	Not Binding	0.388888889
$D$3	Quantities to Generate Cooling Tower	0.722222222	$D$3>=0	Not Binding	0.722222222
$E$3	Quantities to Generate Import	0.888888889	$E$3>=0	Not Binding	0.888888889

Let's look more closely at the Status and Slack cells in this report

Screenshots by Scott Cunningham, using Microsoft Excel Solver.

Sensitivity Report

Provides an indication of how robust your solution is under uncertainty

Report Created: 25/09/2007 17:27:17

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$C$3	Quantities to Generate No Cooling Tower	212.27	0.00	0.010598374	0.044650273	0.009787775
$D$3	Quantities to Generate Cooling Tower	642.67	0.00	0.022585817	0.005872666	1E+30
$E$3	Quantities to Generate Non-Polluting	0.00	0.01	0.065671063	1E+30	0.010422415
$F$3	Quantities to Generate Import	378.27	0.00	0.055248648	0.010422415	0.014681666

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$H$8	Thermal Standards Generated	2.989378054	-8.930054665	2.989378054	1.651257923	1.061366678
$H$9	Generation Limits 1 Generated	212.2737355	0	542.5252202	1E+30	330.2515847
$H$10	Generation Limits 2 Generated	642.669792	-0.005872666	642.669792	353.7895392	550.4193078
$H$11	Generation Limits 3 Generated	0	0	1228.587236	1E+30	1228.587236
$H$12	Generation Limits 4 Generated	378.2660156	0	1380.106555	1E+30	1001.84054
$H$7	Energy Demand Generated	1233.209543	0.055248648	1233.209543	1001.84054	378.2660156

We'll look more closely at reduced costs, allowable increases and decreases, and shadow prices

Screenshots by Scott Cunningham, using Microsoft Excel Solver.