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Optimisation in Excel

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Overview

- Objectives
  - Solve optimisation (maximisation and minimisation) problems using the Excel Solver:
    - What Solver will do
    - Problems it can solve
    - Limitations of Solver
  - Solver hugely extends the power of Excel by allowing iterative procedures to be carried out very quickly

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Goal Seek

- Basic Excel has a basic backwards calculation routine called ‘Goal Seek’, which is found under ‘What If Analysis’ on the Data tab.
- In this, you specify a value for a given cell (in ‘Set cell’ and ‘To value’) and the cell you can change to get it (the ‘By Changing Cell’). Goal Seek calculates the value for the changing cell.
- Goal Seek is very limited. It only allows one variable, does not allow constraints and sometimes requires several goes to get it right.

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The Excel Solver

- If you want to use Goal Seek, look it up. We are just going to use the more sophisticated Excel *Solver*.
- Solvers are programs that can do the same as Goal Seek but also much more. There is a basic solver add-in with Excel, provided by Frontline Systems, but more sophisticated paid for versions are available.
- Help on Solver is available from http://www.solver.com/excel-solver-help.

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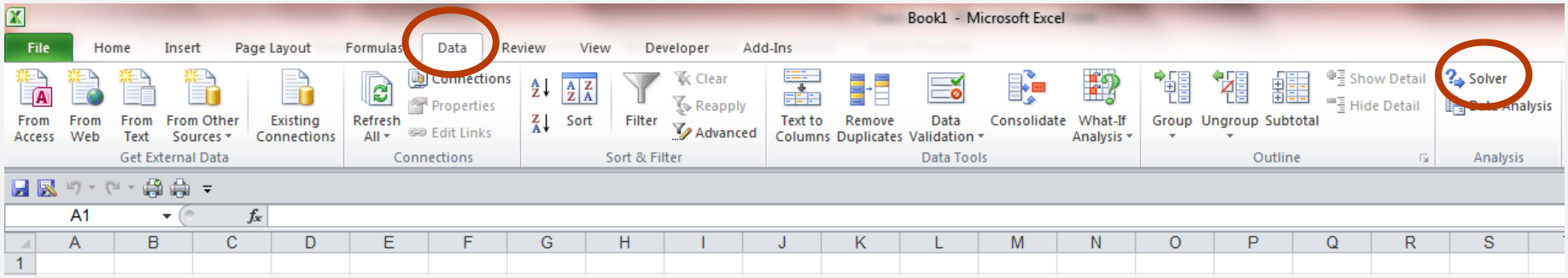
Finding Solver

- In Excel 2010, Solver can be found on the far right of the ‘Data’ tab in the ribbon.



- If it is not there, you will need to activate it. To do this, go to ‘Options’ – ‘Add-ins’ on the ‘File’ tab. That will bring up the following dialogue box.

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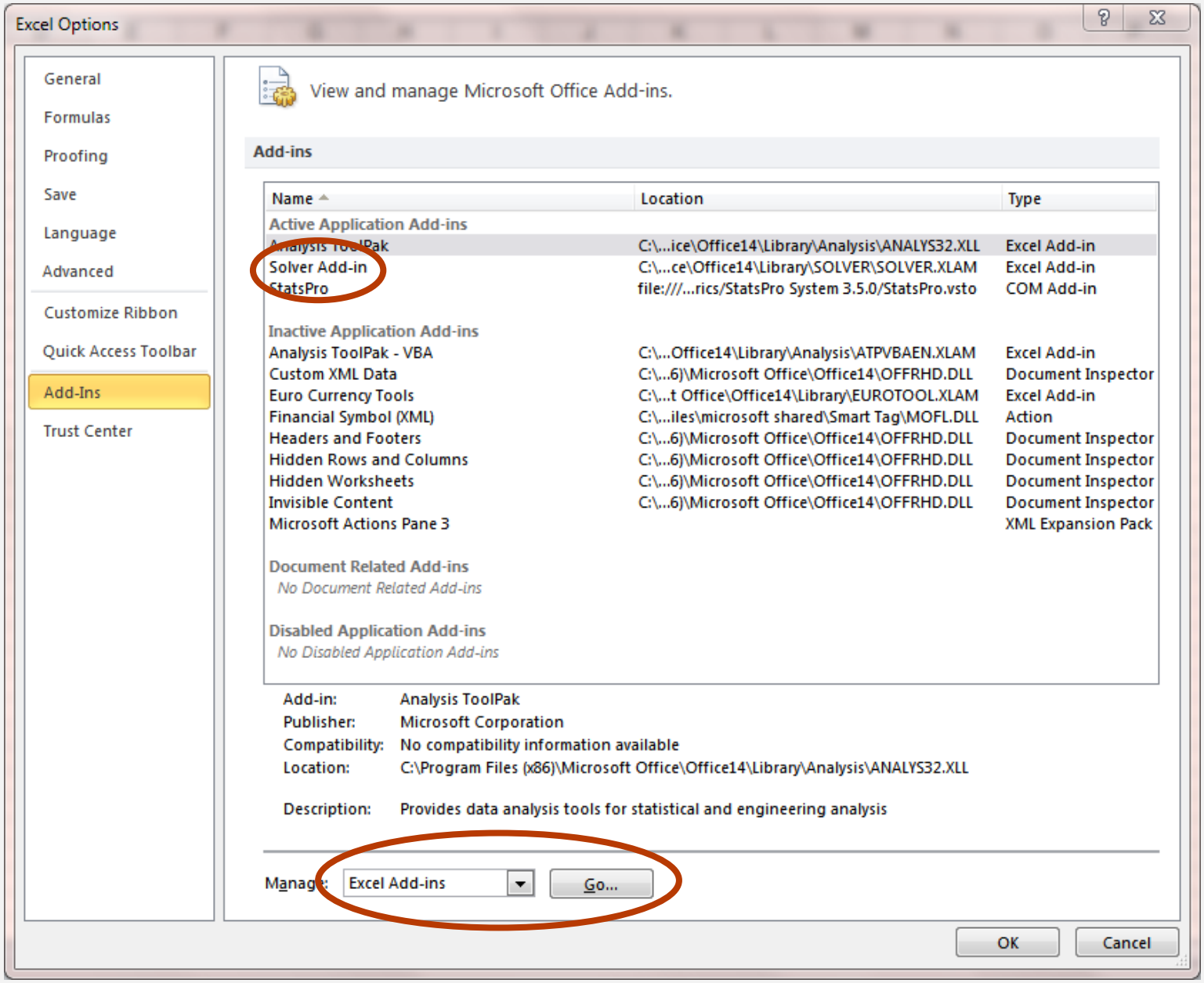

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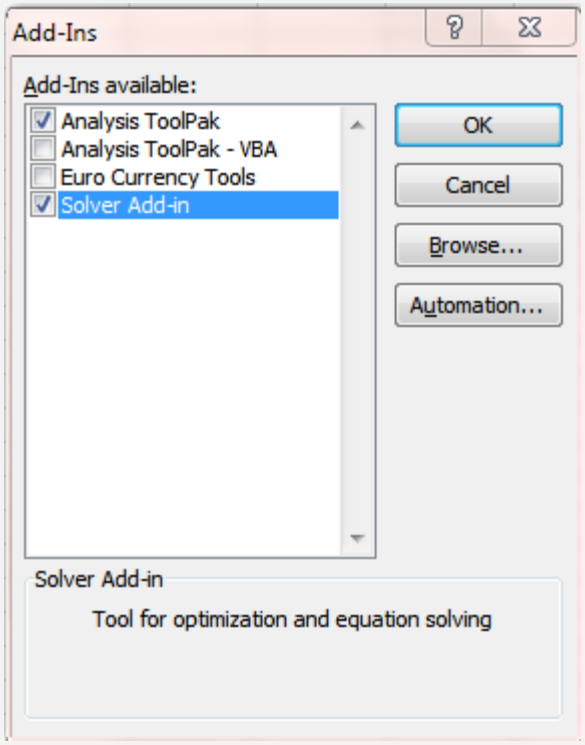
Activating Solver

- Clicking ‘Go’ on ‘Manage Excel Add-ins brings up this dialogue box.



- Now simply check the box next to ‘Solver Add-in’ and it will appear in the ribbon.
- It is already checked here because it has already been activated on my computer.

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What does Solver do?

Even the basic solver packaged with Excel is a very powerful tool. It can be used for:

- Backwards calculations
- Finding maxima and minima of functions
- Finding optimal solutions to problems such as LPs

LP (Linear Programming) is finding min or max of a **linear** function subject to **linear** constraints, e.g.

find max of $f(x,y,z)=2x+3y-7z$ subject to
constraints: $2x+z \leq 5$

$3x+y-z \leq 7$

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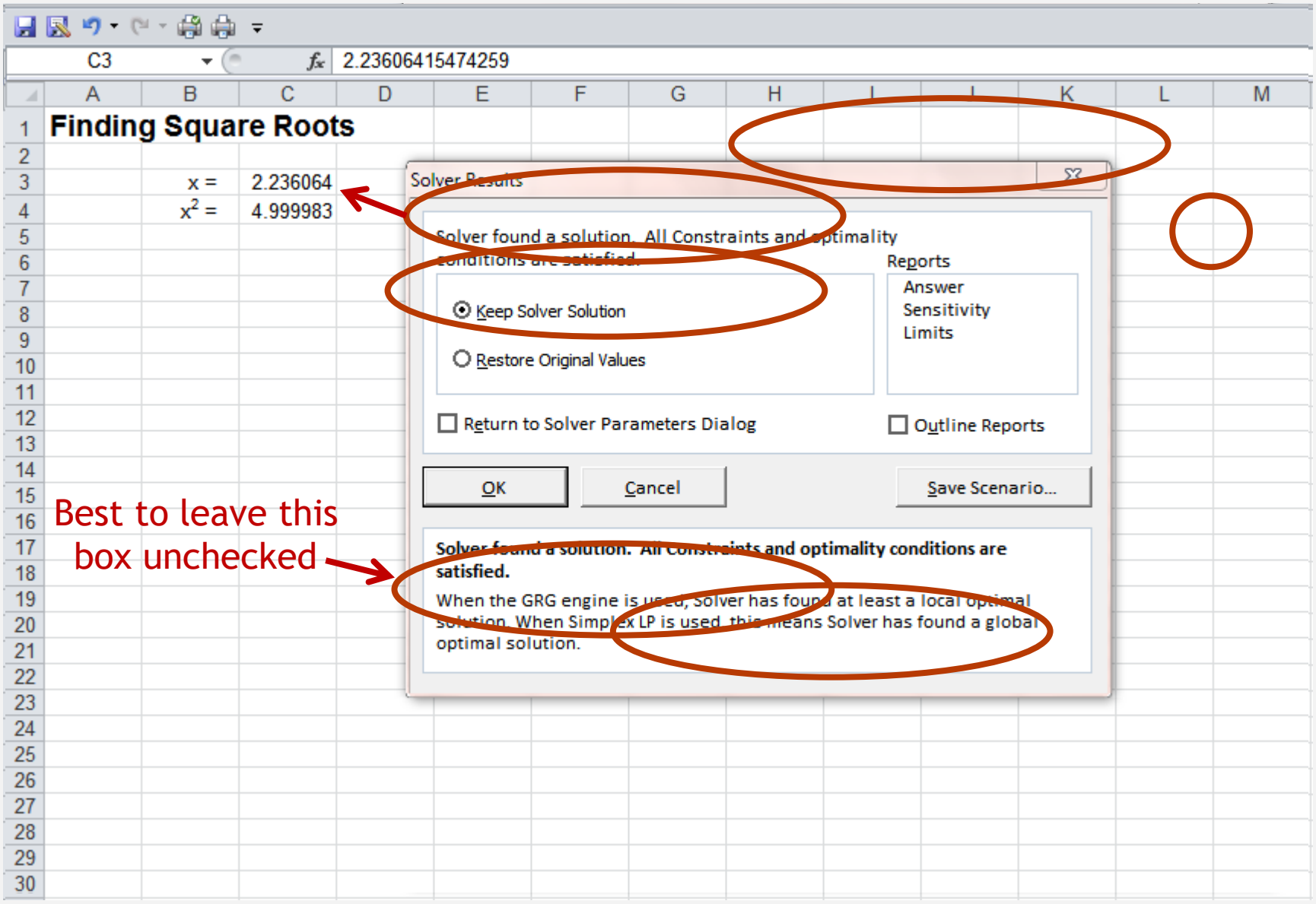
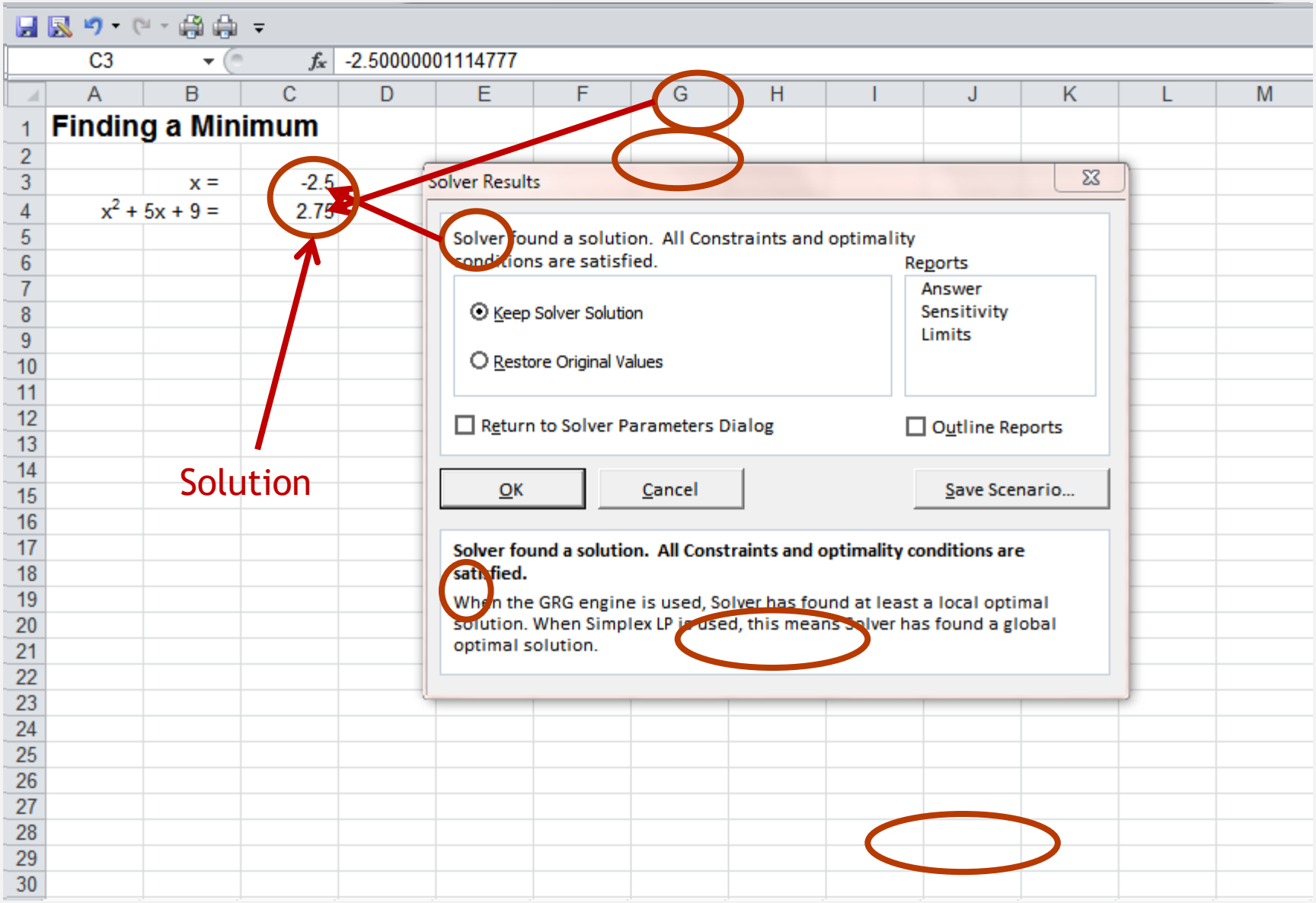
What does Solver do?

- Examples of the uses of Solver can be found in the spreadsheet Solvsamp.xls in the Microsoft Office Samples folder on your computer.
- Here are some more.


C3
2.23606415474259
Finding Square Roots
x =
2.236064
x² =
4.999983
Solver Results
Solver found a solution. All Constraints and optimality conditions are satisfied.
Reports
Answer
Sensitivity
Limits
Keep Solver Solution
Restore Original Values
Return to Solver Parameters Dialog
Outline Reports
OK
Cancel
Save Scenario...
Solver found a solution. All Constraints and optimality conditions are satisfied.
When the GRG engine is used, Solver has found at least a local optimal solution. When Simplex LP is used, this means Solver has found a global optimal solution.
Best to leave this box unchecked


C3
-2.50000001114777
Finding a Minimum
x =
-2.5
x² + 5x + 9 =
2.75
Solution
Solver Results
Solver found a solution. All Constraints and optimality conditions are satisfied.
Reports
Answer
Sensitivity
Limits
Keep Solver Solution
Restore Original Values
Return to Solver Parameters Dialog
Outline Reports
OK
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Solver found a solution. All Constraints and optimality conditions are satisfied.
When the GRG engine is used, Solver has found at least a local optimal solution. When Simplex LP is used, this means Solver has found a global optimal solution.

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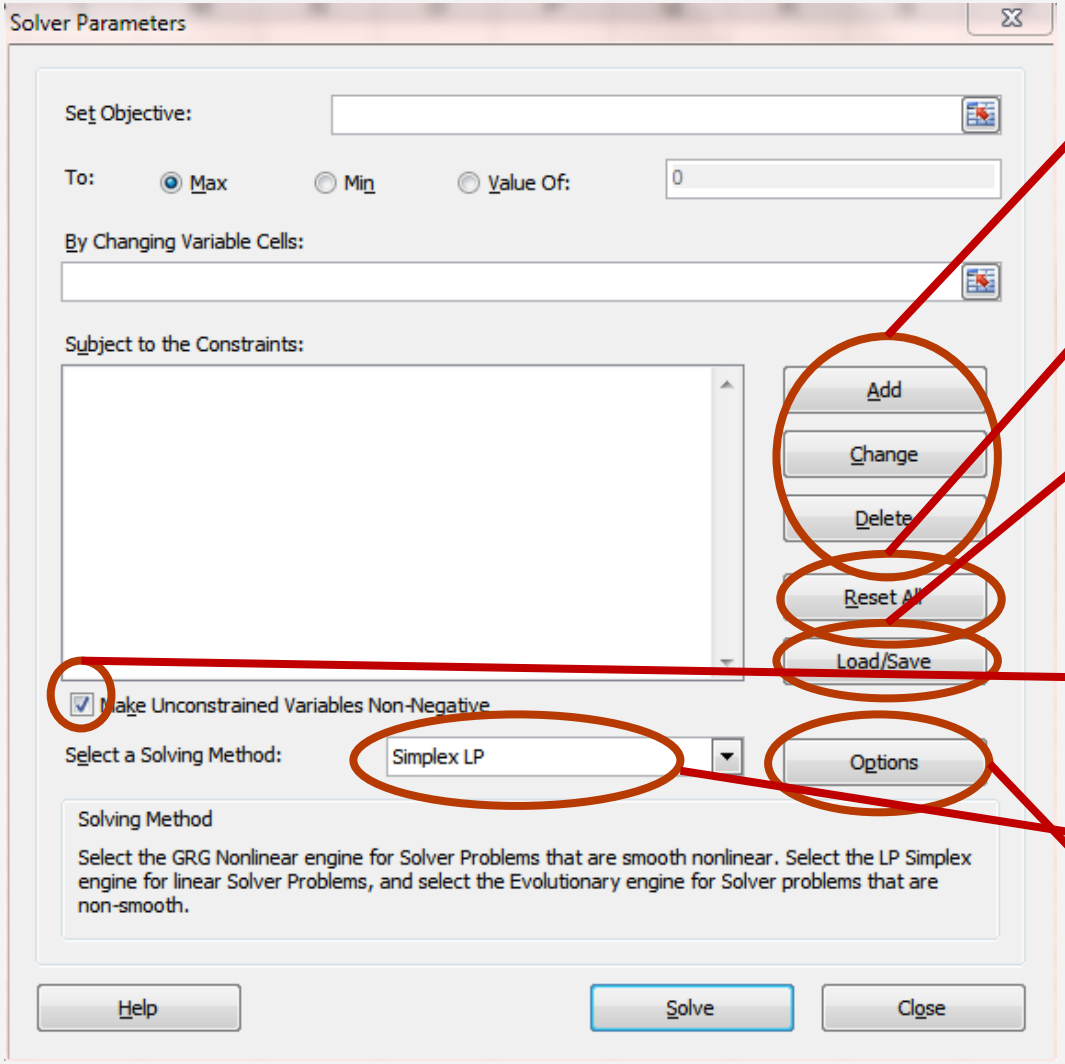
Solver options



Add, change or delete constraints

Reset all options to default values

Save solutions or load saved solutions

Check if only positive values permitted

Simplex LP for linear problems

See next slide

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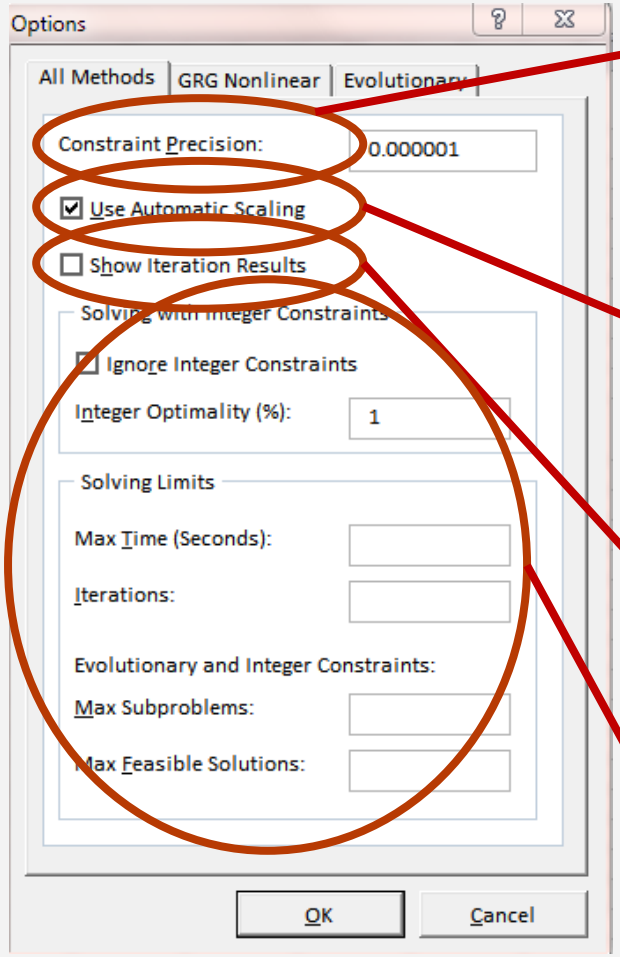
More options



Precision of results. Higher precision will increase calculation times but this will not usually be a problem for LP problems

Scales variables to similar magnitudes to reduce potential error (normally checked)

Shows the intermediate calculations (useful for debugging)

No need to worry about these for LP problems

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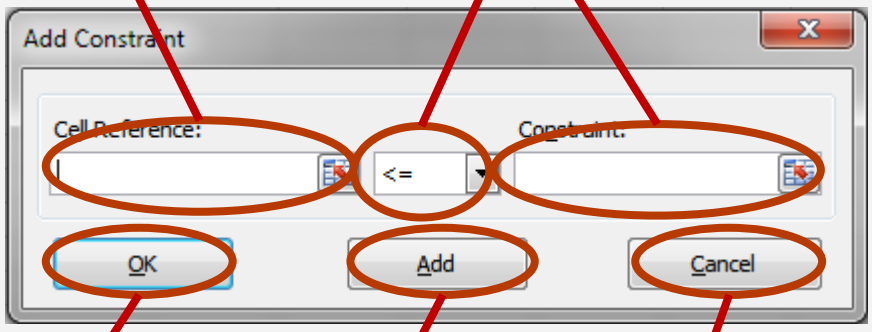
Working with constraints

The cells whose values you want to constrain

The type of constraint

The value you want them constrained to.



- When you click on the 'Add constraint ' option. A new dialogue box allows you to add a range of different types of constraint.
- You select the cells to be constrained and the values or formulae that constrain them. You can have any number of different constraints.
- Then 'OK' to accept or 'Add' to add another constraint.

Accept

Add another

Cancel

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An example

- Suppose you have £100 to save in three different banks, which pay 2%, 2.5% and 3% interest respectively.
- Obviously, you save with the Bank paying the highest interest rate.
- But suppose you want to spread your cash in case a Bank goes bust. Suppose you decide not to invest more than 40% of your money in any one bank.

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Total amount to invest

Amount to invest in each Bank

Total invested =SUM(B6:D6)

Total amount after one year =SUM(B10:D10)

	A	B	C	D	E	F	G
1	**Maximising interest**						
2							
3	Amount to invest		£100				
4						Total	
5		Anytown Bank	Bigtown Bank	Chinatown Bank			
6	Amount invested					£0.00	
7							
8	Interest rate	2.0%	2.5%	3.0%			
9	Amount after one year	102.00%	102.50%	103%			
10	Value after one year	£0.00	£0.00	£0.00		£0.00	
11							
12							

Interest rates and amount after one year

Values after one year

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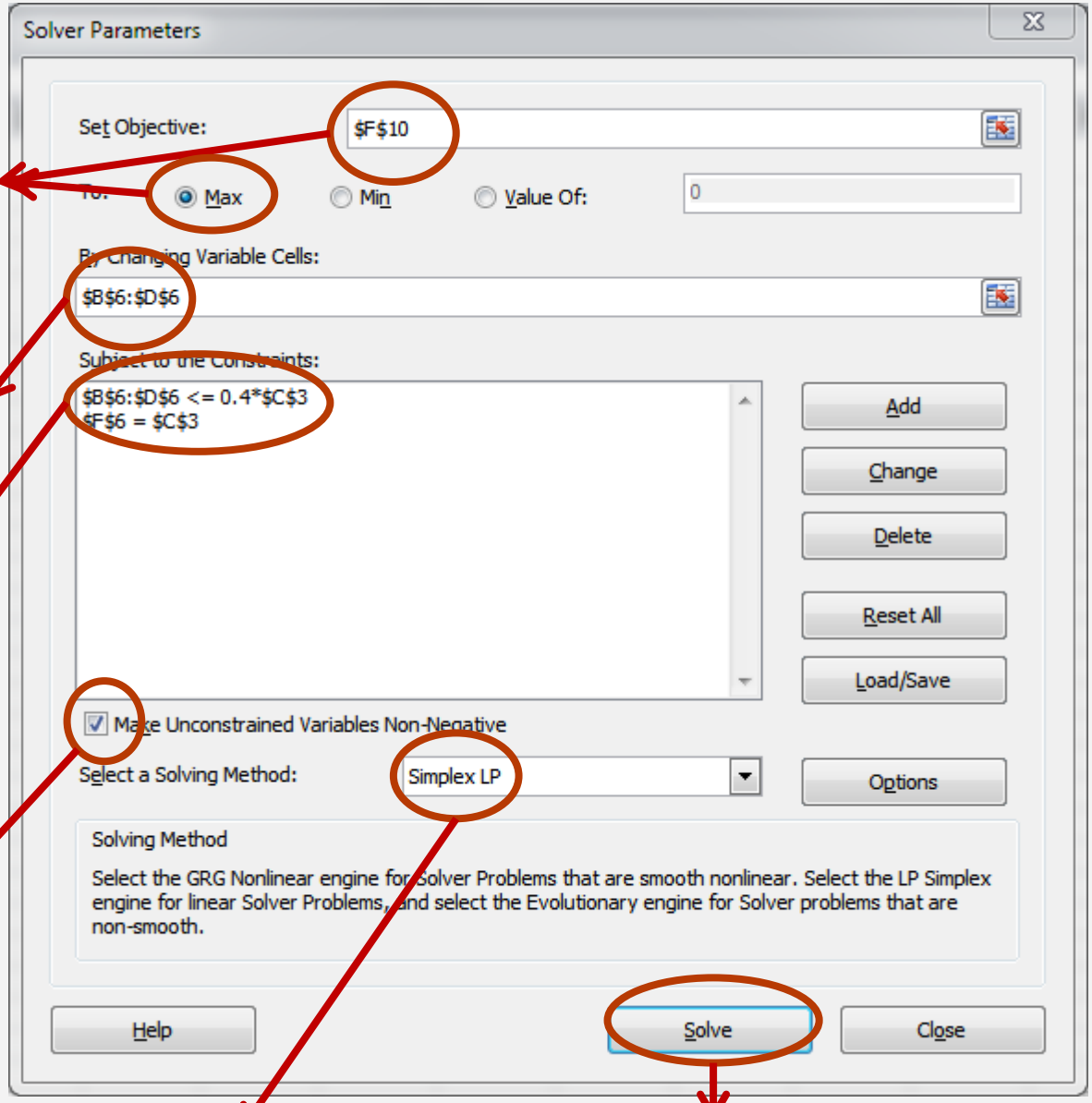
The objective: maximise amount after one year

The variables: amount invested in each bank

The constraints: The amount in each Bank is at most 40% of the total and the sum must equal the total amount

Check this box



Choose Simplex LP

Solve!

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	A	B	C	D	E	F
1	**Maximising interest**					
2						
3	Amount to invest		£100			
4						**Total**
5		**Anytown Bank**	**Bigtown Bank**	**Chinatown Bank**		
6	Amount invested	**£20.00**	**£40.00**	**£40.00**		**£100.00**
7						
8	Interest rate	2.0%	2.5%	3.0%		
9	Amount after one year	102.00%	102.50%	103%		
10	Value after one year	£20.40	£41.00	£41.20		£102.60
11						

Solver calculates these variablest his box

This is the maximum amount after one year

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Constraint types

- Solver has 6 types of constraint:
  - ≤ - the variables selected must be less than or equal to (note, not less than) the constraint value(s)
  - ≥ - the variables selected greater than or equal to (note, not greater than) the constraint value(s)
  - = - the variables selected must be equal to the constraint value(s)
  - int – the variables selected must take integer values
  - bin – the variables selected must take binary (0, 1) values
  - dif – the variables selected must all take different values

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Solving methods

- Solver has three solving methods:
  - Simplex LP (go to Operational Research in Year 3 to find out what this means) will find exact solutions to linear problems and global maximum or minimum solutions to constrained linear solutions. It is fast.
  - Generalized Reduced Gradient (GRG) non-linear is used to find local solutions to smooth non-linear problems. It is usually reasonably fast but you may need to adjust the starting point.
  - Evolutionary is used to find solutions to non-smooth problems. It can be slow and, trial and error may be needed to find the best solution.

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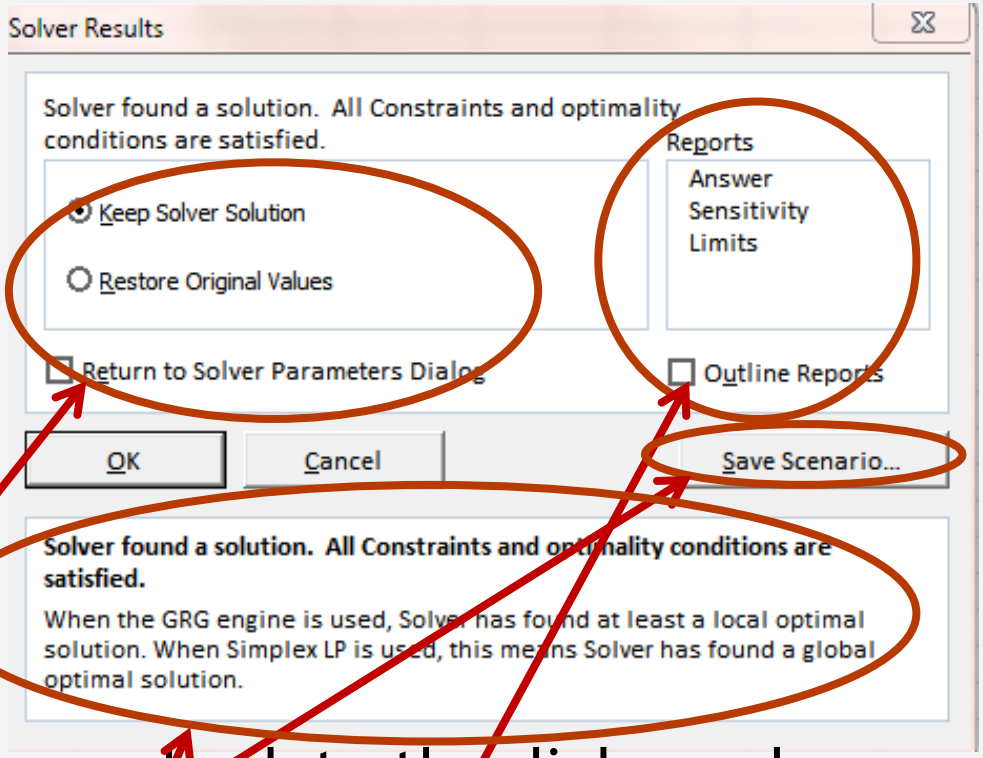
Output options



- The results dialogue box allows you to:
  1. Keep the Solver solution, revert to the original solution or go back to the dialogue box.
  2. Request more detailed reports on the answer, sensitivity and limits, either in outline or in full.
  3. Save the scenario.
- Make the appropriate selection and press ‘OK’.
- Solver reports an error if it does not find a solution.

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Limitations of Solver

- Solver is a powerful tool and will be sufficient for most everyday tasks. Its main limitations are:
  1. It can only handle up to 200 variables. This may seem a lot but with the data sets available these days is insufficient for major tasks.
  2. Its solving algorithms are fairly basic. This can make it slow and sometimes unreliable. This is not a problem for Simplex LP and rarely for GRG non-linear but the Evolutionary method can be slow and will not always give the right answer first time.