



Solver in Excel

Optimize Financial Decisions using Analytics

Created by: Calliope Cortright '23

Intro to Solver

Solver is an add-in for Microsoft Excel that allows the user to optimize the value in a particular cell by allowing the program to change values in other cells. This is useful to make decisions in an environment where the decision maker wants to maximize profit or minimize costs, for example. The program is able to adapt to a variety of situations, and it is useful in many financial situations.

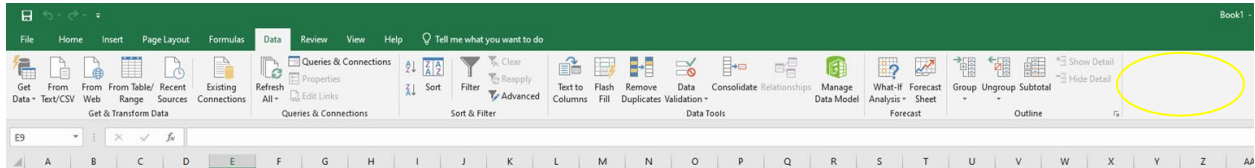
Solver is a tool for data analysis. It gives the user peace of mind with the assertion that a particular decision is the optimal one with respect to a defined output. This tutorial will first give a broad overview of Solver and then explain some use cases within the realm of financial decision-making.

- 1. Accessing Solver.....pg. 2
- 2. Solver Functionality..... pg. 3
- 3. Solver Outputs.....pg. 5
- 4. Use Case: Solver in Capital Budgeting.....pg. 6
- 5. Use Case: Solver in Pricing Decisions.....pg. 8

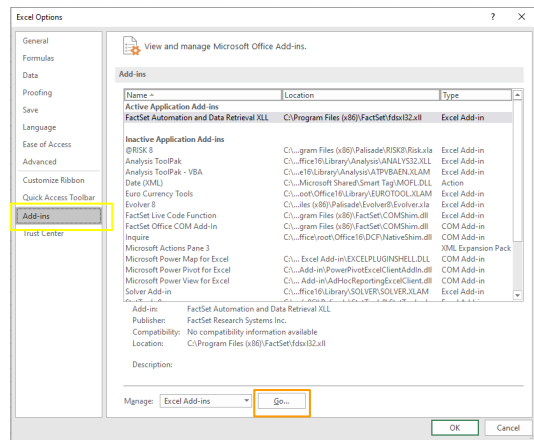
Much of the information in this tutorial and the examples shown are from Professor Terry Reilly, an Associate Professor in the Mathematics, Analytics, Science, and Technology Division. The material in this tutorial is covered in great detail in Professor Reilly's Financial Simulations class. However, Solver is introduced in other classes at Babson, including AQM and Optimization Methods.

Accessing Solver

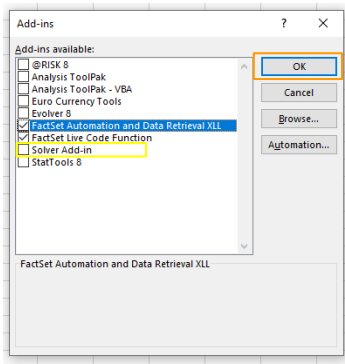
Solver is an Excel add-in, so the first step in using Solver is to ensure that it is loaded on your computer. The Solver option is shown in the Data Tab. Click on the data tab, and look in the area at the far right of the ribbon (shown here in the yellow circle). If Solver is listed here as an option, skip to the next section. If Solver is unavailable, follow the following steps to install the add-in.



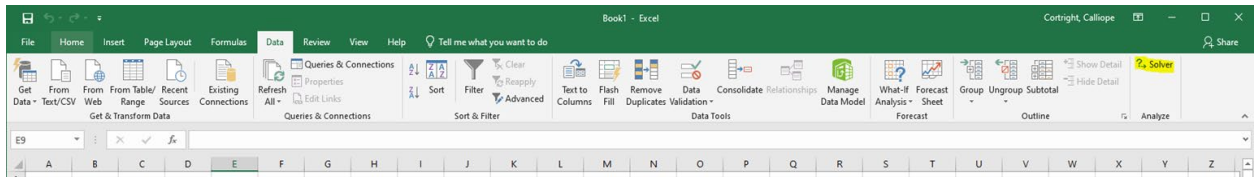
Click on “File” and then on “Options.” This will bring up the menu shown to the right. Along the left of the pop-up window is a menu containing options. Select the “Add-ins” option (highlighted in yellow). From here, Select the “Go...” button (highlighted in orange).



Once you have selected this, a new window will appear with the add-in options (shown to the left). Check the box next to “Solver Add-in” (highlighted in yellow). Once this box is checked, select “OK” (highlighted in orange).



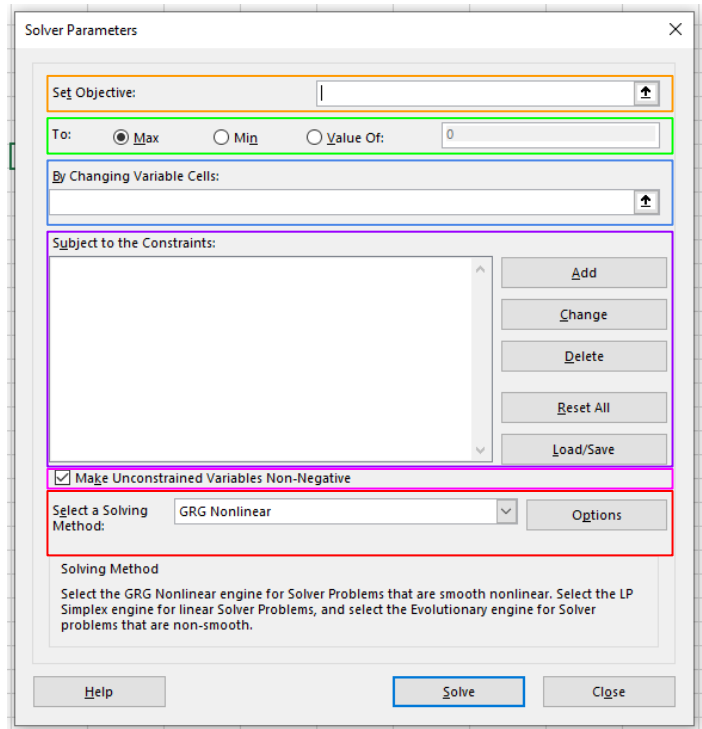
Once you have completed these steps, Solver will show up as an option on your ribbon. Navigate to the “Data” tab and look in the area to the far right of the ribbon. You will find “Solver” (see below).



Solver Functionality

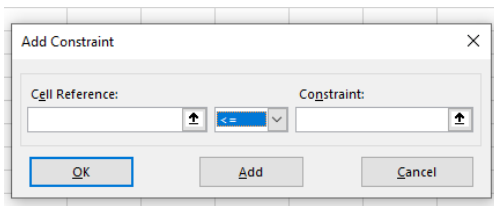
To get acquainted with Solver, click on this “Solver” option in the “Data” tab. The pop-up menu in the image to the right will appear. Before diving into use cases, we must become familiar with each of these inputs. This section will go through each of the inputs highlighted on the image to the right.

Objective Cell: Highlighted in orange is the objective cell. In this box, you will link the cell that you want to optimize. For example, if we want to maximize total profit, we will put the cell for total profit in this box. If we want to minimize risk, we will add the cell that quantifies risk in this cell. Keep in mind you can only optimize one cell. For example, you can not maximize profit while also minimizing risk.



To: Highlighted in green is the area where you must designate whether you want the cell noted above to be maximized or minimized. You also have the option to set that cell to a specific value that you will type into the box to the far left. Keep in mind that you can only select one option here.

Variable Cells: The objective cell cannot change without some of its inputs changing. Variable cells are inputs that you will let Solver change to optimize the objective cell. For example, to maximize profit, you may let Solver change the number of units we produce, so the number of units produced would be a variable cell. In this box, cells must be linked that do not contain a formula (they must be constants) so that Solver has full range to change these cells.



Constraints: Often, in optimization scenarios, the situation is bounded by constraints. For example, in the units produced example, we may only be able to produce a specific number of units. Therefore, we must add these constraints by clicking on the “Add” button. The pop-up to the right will appear. On each side of this inequality, cells must be linked. You can also change the

SOLVER IN EXCEL

4

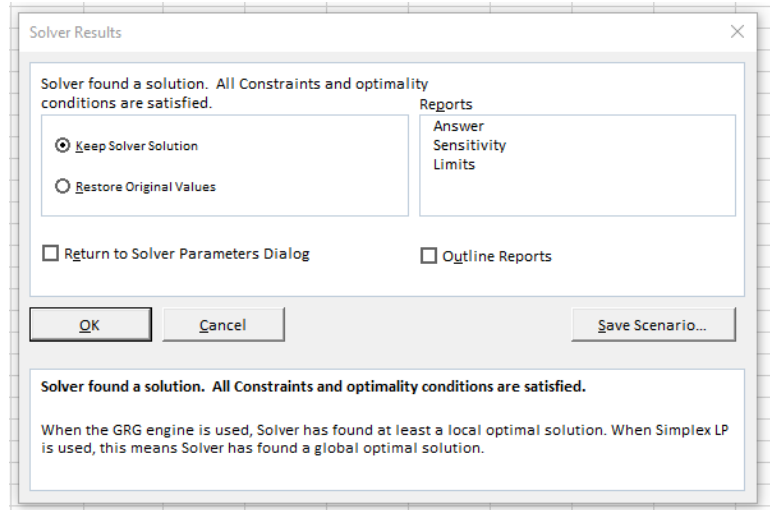
inequality in the middle to be less than or equal to, greater than or equal to, equal to, or “int” (meaning the cell to the left must be an integer), “bin” (meaning the cell to the left must be binary - 0 or 1), or “dif” (meaning the cells to the left must all be different from each other). Once you have filled out this constraint pop-up, click OK to close the window and go back to the Solver window, or click Add to add the constraint and then immediately add another one.

Non-negative toggle: The toggle highlighted in pink above, when selected, will force all variable cells to be positive. Think about if this constraint applies to your situation.

Solving Method: You must choose a solving method in the drop-down menu highlighted in red. “Simplex LP” can only be used when all constraints and the objective are linear (i.e., no products, division, or excel functions). “GRG Nonlinear” should be the default when this is not the case.

Solver Outputs

Once you click “Solve” in the Solver window, the following pop-up will come up. Important insights can be drawn from the Answer report and Sensitivity report (obtained by selecting these options in the “Reports” field before clicking “OK.”)



Answer Report: The answer report will tell you several things about the optimal solution, including the original and final value of all variable cells and if the constraints are binding. Binding constraints can not change without changing the solution. If a constraint is non-binding, the answer report also tells you the slack that exists on this constraint.

Sensitivity Report: The sensitivity report tells you how much the values of the variable cells and the constraints would have to change to change the optimal solution. This is useful in an environment where nothing is certain.

The Answer and Sensitivity Report will be covered in much greater detail in classes that use Solver.

Use Case: Solver in Capital Budgeting

Suppose you are in charge of making a decision in which you must decide which projects to fund among a group of nine projects. You have a budget for the next two years, and you hope to optimize the NPV of the projects in aggregate. The information for each project and the budget are included in the excel image above. Each project has a cost in year one and year two and the NPV that it generates.

	A	B	C	D	E	F	G	H	I	J	K
1											
2											
3		Project Number:	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
4		Year 1 Costs:	\$12.00	\$54.00	\$6.00	\$6.00	\$30.00	\$6.00	\$48.00	\$36.00	\$18.00
5		Year 2 Costs:	\$3.00	\$7.00	\$6.00	\$2.00	\$20.00	\$6.00	\$4.00	\$3.00	\$3.00
6		NPV:	\$14.00	\$17.00	\$17.00	\$15.00	\$40.00	\$12.00	\$14.00	\$10.00	\$12.00
7											
8		Funded?	0	0	0	0	0	0	0	0	0
9											
10		Total NPV	\$0.00								
11											
12											
13			Used		Available						
14		Year 1 Costs:	\$0.00	<=	\$50.00						
15		Year 2 Costs:	\$0.00	<=	\$20.00						
16											
17											
18											

Setting up the Excel for Solver: You must first think of how to set up the Excel sheet in a way that allows for an objective cell and variable cells. In this case, the variable cells (highlighted in green) are created as binary variables to tell the user if these projects are funded or not. Then, the total NPV (highlighted in orange) is calculated using a sumproduct of the binary “funded?” variable and the NPV of the project. It is also important to lay out the constraints in an organized manner. In this case, the constraints (highlighted in blue) are that the costs of the projects selected (calculated as a sumproduct of the year one cost and the binary “funded?” variable) are less than or equal to the available budget.

Running Solver: Click on “Solver” in the Data tab. First, set the objective cell by linking it to cell C10 (the Total NPV). Then click the “Max” toggle to ensure that NPV is maximized. Now, define your variable cells as the green “funded?” cells. For constraints, click “Add,” then select the used cells on the left side and the available cells on the right side. Because these are both “<=,” these two constraints can be added separately or together. Also, the variable cells must be binary, so add this as a constraint. This is a linear problem, so we chose Simplex LP. Clicking “Solve” will give

SOLVER IN EXCEL

7

you the following solution. This tells us that we should fund projects 1, 3, 4, 6, and 9 to optimize NPV.

The Solver Parameters dialog box is configured as follows:

- Set Objective:** \$C\$10
- To:** Max Min Value Of: 0
- By Changing Variable Cells:** \$C\$8:\$K\$8
- Subject to the Constraints:**
 - \$C\$14:\$C\$15 <= \$E\$14:\$E\$15
 - \$C\$16:\$K\$17 = binary
- Make Unconstrained Variables Non-Negative
- Select a Solving Method:** Simplex LP

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2												
3		Project Number:	One	Two	Three	Four	Five	Six	Seven	Eight	Nine	
4		Year 1 Costs:	\$12.00	\$54.00	\$6.00	\$6.00	\$30.00	\$6.00	\$48.00	\$36.00	\$18.00	
5		Year 2 Costs:	\$3.00	\$7.00	\$6.00	\$2.00	\$20.00	\$6.00	\$4.00	\$3.00	\$3.00	
6		NPV:	\$14.00	\$17.00	\$17.00	\$15.00	\$40.00	\$12.00	\$14.00	\$10.00	\$12.00	
7												
8		Funded?	1	0	1	1	0	1	0	0	1	
9												
10		Total NPV	\$70.00									
11												
12												
13			Used		Available							
14		Year 1 Costs:	\$48.00	<=	\$50.00							
15		Year 2 Costs:	\$20.00	<=	\$20.00							
16												
17												

Use Case: Solver in Pricing Decisions

Often Solver can be used internally in a firm to decide the optimal price for a product in terms of profit given a particular elasticity of demand. The excel below shows this problem.

Setting up Excel:

Suppose that our company sells suits. It costs us \$225 to make each suit. This is not a number we can change, but we can change the amount that we sell the suits for. Therefore, the price cell is highlighted in green because it is a

	A	B	C	D	E
1					
2					
3	Product:	Suit		Profit Model	
4	Cost/Suit	\$ 225.00		Suit Price	\$ 317.61
5	Current Price	\$ 350.00		Suit Demand	365
6				Revenue	\$ 115,828
7	Current Demand (Suits/day)	300		Cost	\$ 82,055
8	Elasticity	2.33%		Suit Profit	\$ 33,774
9					
10	Linear Demand Curve				
11	Slope:	-1.9971			
12	Intercept:	\$ 999.00			
13					

decision variable. The elasticity is also set. The linear demand curve is defined using a slope and intercept, the former is a function of the current price, current demand, and elasticity, and the latter is a function of current price and current demand. We are maximizing the profit obtained by suit sales (highlighted in orange).

Running Solver: Click “Solver” in the “Data” tab. The first step is to set the objective value to the profit and indicate that we are

trying to maximize this number. Next, indicate that our variable cell is the Suit Price in E4.

There are no constraints in this model, so leave this blank. This is a nonlinear problem because multiplication and division is used to influence the suit

profit, so GRG Nonlinear is selected. Click “Solve,” and the optimal suit price comes out to \$317.61.