

Excel Solver¹

Solver is a feature of Excel that facilitates the solution of optimisation- and goal seeking problems. The general structure of this tool is quite similar to that of *Goal Seek*: We have to specify a target cell (together with a corresponding target value) and variable cells which exert an influence on the target cell. However, contrary to the Goal Seek tool, several cells can be simultaneously varied by Solver. Moreover, Solver allows us to introduce constraints to the optimisation-/goal seeking problems. The following example explains the handling of Solver:

	A	B	C	D	E
1	Maximisation of Contribution Margin				
2					
3		Goods			
4		A	B		
5	Revenue per unit	SFr. 1'000	SFr. 3'000		
6	Direct Cost per unit	SFr. 700	SFr. 2'500		
7	Contribution Margin per unit	SFr. 300	SFr. 500		
8					
9				Capacities	
10	Production time in [h/ME]			used	available
11	Machine I	1	2	0	170
12	Machine II	1	1	0	150
13	Machine III	0	3	0	180
14					
15	Units of Goods Produced	0	0		
16	Contribution Margin	SFr. 0	SFr. 0		
17					
18	Total Contribution Margin			SFr. 0	
19					

Example:

A firm produces two goods A and B. Each good yields different revenues (B5,C5) and causes certain direct costs (B6,C6). By computing the difference between revenue and direct cost, we get the *contribution margin*. (B7,C7). The production of both goods requires the use of three machines I, II and III. In order to produce 1 unit of good A, we need 1 hour of machine I and 1 hour of machine II (B11-B13). Production of good B, however, is more involved. In order to produce 1 unit of B, it takes 2 hours on machine I, 1 hour on machine II and 3 hours on machine III (C11-C13). When producing the goods, we have to take into account that each machine can only be run for a limited number of hours. The total capacity of machines I, II and III are respectively 170, 150 and 180 hours (E11-E13).

The problem is to find the number of units of goods produced (for both goods), such that **the total contribution margin is maximised subject to the capacity constraints**.

To solve this problem, we have to set up an **objective function** and several **constraints**. The objective function has to be specified within the Excel worksheet, while the constraints need merely be stated in the Solver window.

¹ This short note draws on a handout formerly used in the lecture “Einführung in die Wirtschaftsinformatik” by the Institut für Wirtschaftsinformatik of the University of Bern. Translated and rearranged by Juerg Adamek, 2006. Any errors are, of course, mine.

	A	B	C	D	E
1	Maximisation of Contribution Margin				
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7	Contribution Margin per unit	SFr. 300	SFr. 500		
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9				Capacities	
10	Production time in [h/ME]			used	available
11	Machine I	1	2	0	170
12	Machine II	1	1	0	150
13	Machine III	0	3	0	180
14					
15	Units of Goods Produced	0	0		
16	Contribution Margin	SFr. 0	SFr. 0		
17					
18	Total Contribution Margin			SFr. 0	
19					

Objective Function

In order to figure out what the total contribution margin is, we first of all have to find the contribution margins per unit for each good.

The **contribution margin per unit** is the difference between the revenue per unit and the cost per unit:

- Good A: Cell B7: = B5-B6
- Good B: Cell C7: = C5-C6

The **total contribution margin of each good** is then found by multiplying the contribution margin per unit with the number of units of goods produced:

- Good A: Cell B16: = B7*B15
- Good B: Cell C16: = C7*C15

Finally, the **total contribution margin** is the sum of the total contribution margins of goods A and B:

- Total contribution margin: Cell D18: = B16+C16

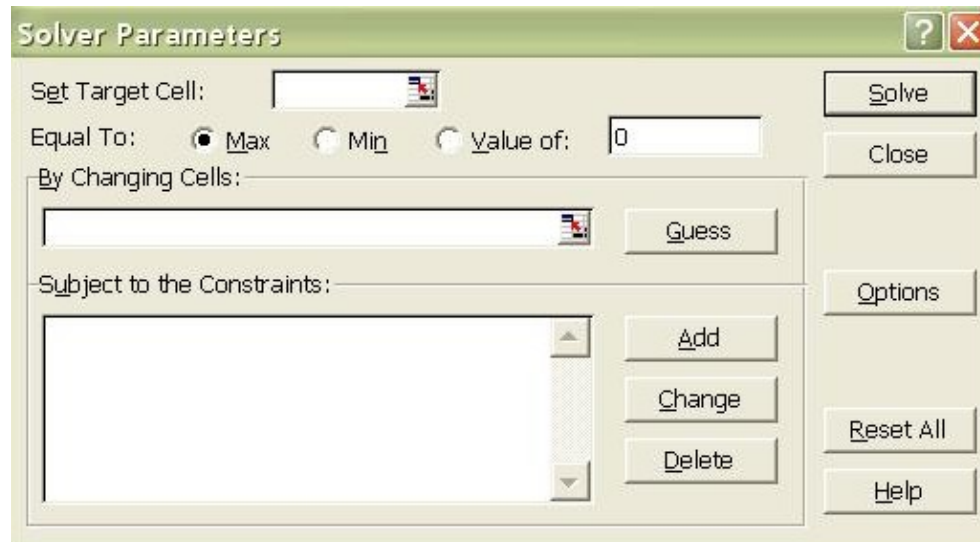
Constraints

There are three constraints involved in the present maximisation problem, reflecting the fact that each of the three machines' capacity limit must not be exceeded. However, before we are able to specify these constraints in the Solver, we need to take some preliminary steps. In particular, we have to find and state formulas which compute the number of machine hours used in production of good A and B. For each machine, this can be computed by multiplying the production times with the number of units of goods produced:

- Used capacity of machine I: Cell D11: = B11*\$B\$15+C11*\$C\$15
- Used capacity of machine II: Cell D12: = B12*\$B\$15+C12*\$C\$15
- Used capacity of machine III: Cell D13: = B13*\$B\$15+C13*\$C\$15

These formulas are put in cells D11-D13. Having done so, the three constraints can be specified as follows:

- D11 ≤ E11
- D12 ≤ E12
- D13 ≤ E13

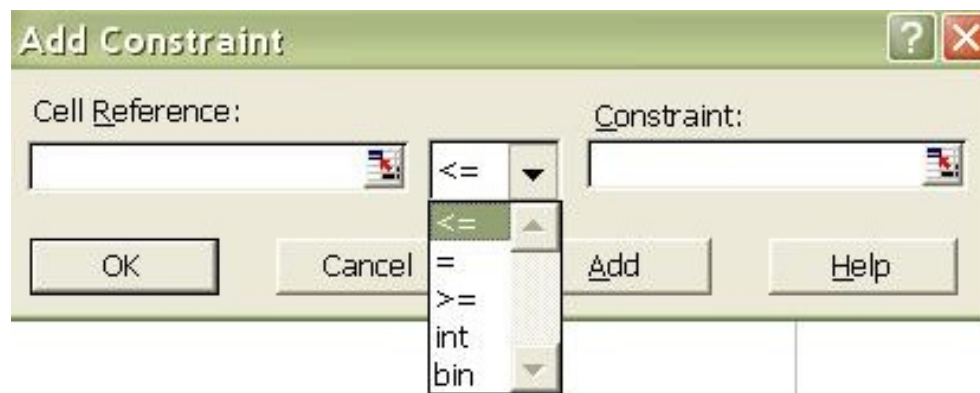


Having specified the problem, we can now solve it with the aid of Solver.

Solver is found in the menu “Tools”. After a click on “Solver” the dialogue box **Solver Parameters** pops up.

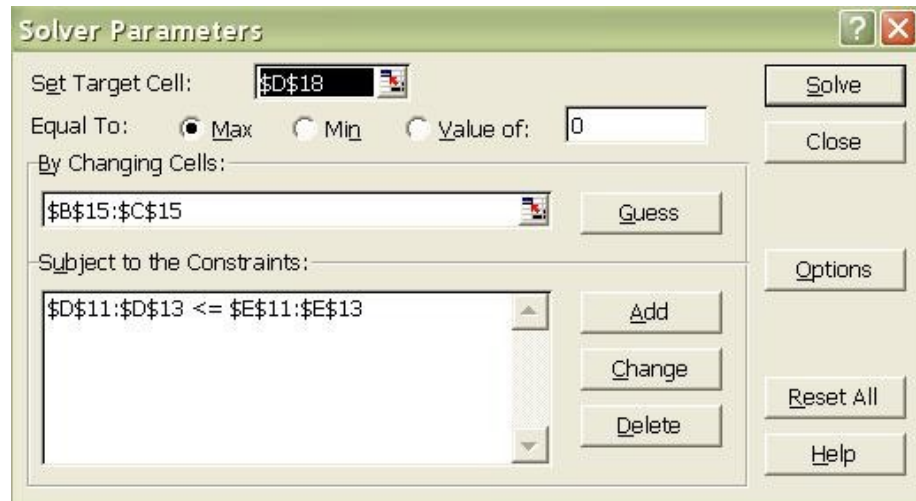
In analogy to the Goal Seek tool, we firstly have to define the **target cell** and what this target cell should be **equal to**. There are three options available:

- If **Max** is chosen, the value of the target cell will be maximised.
- If **Min** is chosen, the value of the target cell will be minimised.
- By choosing **Value of**, we can determine the value that the target cell should attain.



As a next step, we have to indicate which cells can be varied in order to reach the target value. This can be done in the section **By Changing Cells**. In contrast to Goal Seek, more than one variable cell can be specified here.

Eventually, we have to define the constraints to our optimisation problem. By clicking on “Add” we reach the dialogue box **Add Constraint**, where we can specify the restrictions. We firstly have to state in **Cell Reference**, which cells are required to meet the restriction. In **Constraint** we then have to enter the cells which contain the restriction. Moreover, an operator has to be selected in order to characterise the constraint. A click on “OK” concludes the definition of the restriction. Further constraints can be added by repeating the procedure just described.

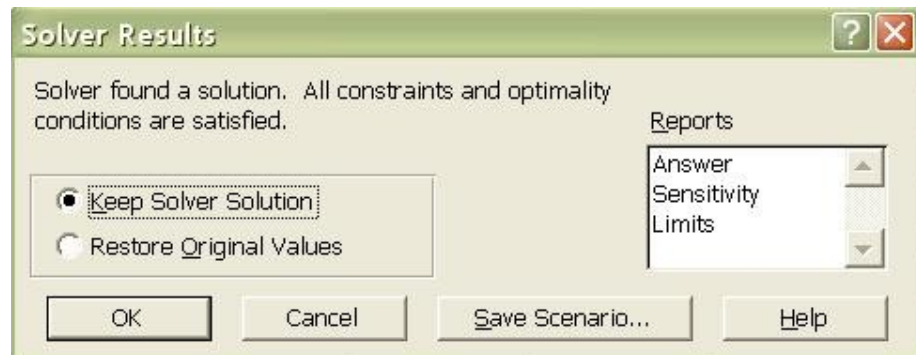


Let us now use the Solver tool to compute a solution to our above problem of maximising the total contribution margin.

For this purpose, we have to enter all the necessary specifications in the dialogue box **Solver Parameters**. Before we start the solution procedure (by clicking on “Solve”) the dialogue box might look as follows:

- Target Cell: \$D\$18
- Equal to: Max
- Changing Cells: \$B\$15:\$C\$15
- Constraints: \$D\$11:\$D\$13<=\$E\$11:\$E\$13

Note: In order to avoid negative numbers in the result, it is sometimes advisable to introduce non-negativity constraints.



After the solution of the problem, the window **Solver Results** pops up. It contains brief information on whether the computations led to a solution or not. In the present case a solution that satisfies all constraints and optimality conditions was found.

In addition to that, Excel allows you to save the solution as a scenario and provides you with three reports:

Answer report:

This report lists the values of the target cell and variable cells before and after the solution. Moreover, we are given further information on the constraints.

Sensitivity report:

This report provides information on how sensitive the solution is to small changes in the constraints or in the formula of the target cell.

Limits report:

This report lists the target cell and the variable cells together with their actual values, upper and lower limits and target values.

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7	Contribution Margin per unit	SFr. 300	SFr. 500		
8					
9				Capacities	
10	Production time in [h/ME]			used	available
11	Machine I	1	2	170	170
12	Machine II	1	1	150	150
13	Machine III	0	3	60	180
14					
15	Units of Goods Produced	130	20		
16	Contribution Margin	SFr. 39'000	SFr. 10'000		
17					
18	Total Contribution Margin			SFr. 49'000	
19					

Having clicked „OK“ in the **Solver Results** window, the results of the Solver are transferred to the current worksheet. Accordingly, the total contribution margin is maximised if we produce

- **130 units** of good A and
- **20 units** of good B.

Thereby the capacities of machines I and II are fully exploited, whereas only a third of the capacity of machine III is used (D11 – D13).

The two goods yield a contribution margin of respectively

- Product A: **SFr. 39'000** (Cell B16)
- Product B: **SFr. 10'000** (Cell C16)

On the whole, the total contribution margin realised through this production plan is equal to **SFr. 49'000** (Cell D18).