CT5141 Lab Week 3

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There is no `sol03.pdf` this week, as the solutions are given in `.xlsx` files in Bb.

Software for LP and IP

Today we'll see how to solve IP problems in Excel Solver (and the same will work for LP).

Installing/running Solver

"Solver" is the name of an Excel tool for optimisation. Some other spreadsheet applications offer variants with the same functionality.

- On Excel, Solver is probably already installed, but you might need to enable it: https://support.office.com/en-ie/article/load-the-solver-add-in-in-excel-612926fc-d53b-46b4-872c-e24772f078ca. Go to the Tools menu to run it.
- Office 365 (the web version) does not offer Solver.
- LibreOffice Calc has a Solver tool built-in. Go to the Tools menu to run it.
- Google Sheets http://docs.google.com has an add-in called Solver. Go to Add-Ons – Get Add-Ons. Then Add-Ons – Solver – Start. (There is another one called OpenSolver, but Google have messed up the authentication for it, so it doesn't work at the moment.)
- Numbers on MacOS does not offer Solver.
- LibreOffice and Google Sheets can import Excel files (e.g. the examples supplied in Bb). However, they may not import/export Solver data correctly.

Exercise

1. Check that you have Solver.

Recreation Centre

Recall the Recreation Centre problem:

- x_i means **whether** to build facility i
- 1: Swimming pool, 2: Tennis centre, 3: Athletic field, 4: Gym

Maximise expected daily usage: $300x_1 + 90x_2 + 400x_3 + 150x_4$
Subject to:

$$35,000x_1 + 10,000x_2 + 25,000x_3 + 90,000x_4 \leq 120,000$$
$$4x_1 + 2x_2 + 7x_3 + 3x_4 \leq 12 \text{ acres}$$
$$x_1 + x_2 \leq 1 \text{ facility}$$

We can program the model in Excel (see the file `LP_Recreation_Centre.xlsx`):

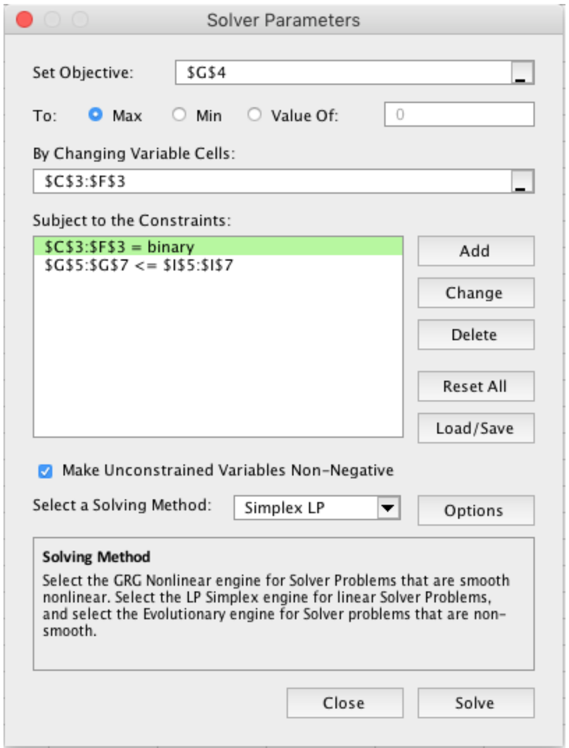
	A	B	C	D	E	F	G	H	I
1			**Swimming pool**	**Tennis centre**	**Athletic field**	**Gym**			
2		**Variables**	x1	x2	x3	x4			
3		**Values**	0	0	0	0			
4	**Maximise**	**Usage**	300	90	400	150	0		
5	**Subject to**	**Cost**	35000	10000	25000	90000	0	<=	120000
6		**Land area**	4	2	7	3	0	<=	12
7		**Selection**	1	1	0	0	0	<=	1

Notice that in the blue cells we use a formula `SUMPRODUCT` to implement a linear formula, multiplying coefficients (one row of green cells) by variable values (yellow). We use `SUMPRODUCT` in exactly the same way for the objective function and the left-hand side of each constraint. The right-hand side of the constraints are written as constants in red. We write `<=` symbols but these are just for documentation: they have no effect. After entering the formula once we can "copy down", but notice how we use the $ sign so that we always multiply a fixed row by a changing row.

Exercise

2. Try out some values for the variables to observe how the objective function and the constraint LHS changes. Find at least one feasible point, and one infeasible point. Can you find the optimum by hand?

Next we open Solver and tell it **which cells** hold the variables and the objective function, and specify that we are maximising. We must also tell it about the constraints. We can write that an entire cell range (blue) is `<=` another cell range (red). We must also specify that decision variables are binary as shown.



Finally, we can click `Solve` and it finds the optimum. It gives it to us by changing the values in the variable cells:

	A	B	C	D	E	F	G	H	I
1			Swimming pool	Tennis centre	Athletic field	Gym			
2		Variables	x1	x2	x3	x4			
3		Values	1	0	1	0			
4	Maximise	Usage	300	90	400	150	700		
5	Subject to	Cost	35000	10000	25000	90000	60000	<=	120000
6		Land area	4	2	7	3	11	<=	12
7		Selection	1	1	0	0	1	<=	1

Exercise

3. Read the solution and interpret it fully.

Covid-19 Lockdown Policy

This article recommends a strong lockdown policy followed by some easing of lockdown measures: https://medium.com/@tomaspueyo/coronavirus-the-hammer-and-the-dance-be9337092b56.

In the first phase ("the hammer"), we try to get the reproductive number (number of people infected by each case) R as low as possible using all possible measures. In the second phase ("the dance"), the goal is to keep $R \leq 1$, at minimal economic and social cost. The article supplies some fictitious data to illustrate the decision that a political leader would be faced with in the second phase. See `Covid-19-R-IP.xlsx`. Notice that the layout is different compared to the Recreation Centre problem: decision variables are now in a column `G8:G23` as opposed to a row. It doesn't matter: `SUMPRODUCT` can use either.

Exercise

4. Use `SUMPRODUCT` to calculate R and Cost in the cells indicated.
5. Play with the variables to see how R and Cost change. Can you find a good solution?
6. Open Solver and program in the decision variables, objective, and constraints ($R \leq 1$ and decision variables binary).
7. Run Solver and interpret the solution.
8. Solution in Bb: `Covid-19-R-IP-soln.xlsx`.

Call centre workers

A call centre processes insurance claims using a pool of data processing operators some of whom are permanent, some are temporary. Permanent operators process 16 claims, generate 0.5 errors and are paid €96 per day. Temp. operator process 12 claims with 1.4 errors and are paid €70 per day.

The company must process at least 450 claims per day, has 40 hot desking units available and wants to limit errors to no more than 25/day. The supervisor wants to determine the number of permanent and temp operators to schedule for the day's work rota to minimise costs.

Exercise

9. Formulate the problem by defining the decision variables, and writing the objective and constraints.
10. Program it in Solver, and solve.
11. Solution in Bb: `Call-Centre-IP-soln.xlsx`, or a read-only copy in Google Sheets: https://docs.google.com/spreadsheets/d/19SwRLQt7Po3v2cUdNMGRtRCiBlrtvp6Ia7rCe-VI8cs/edit?usp=sharing