

What-If Analysis
© 2006 Samuel L. Baker

Assignment 9 is on page 4.

What-if analysis takes advantage of electronic spreadsheets' ability to quickly recalculate formulas when numbers are changed. You can test the effect of changes in one or more parameters, finding the best by trial and error.

Here is an example. It is a simplified version of a real problem faced by a local medical practice group. I may have simplified the problem so much that you will guess the answer without a spreadsheet. Hopefully, I have put in enough obfuscation so that you will use the spreadsheet to do the what-if analysis.

A medical practice wants to get the most revenue it can from the 300 minutes of daily doctor time and the 300 minutes of daily nurse time it has available. The practice can do either hospital room visits or outpatient clinic visits. Each hospital room visit requires 20 minutes of doctor time and 10 minutes of nurse time. Each outpatient clinic visit requires 10 minutes of doctor time and 20 minutes of nurse time. The clinic is very close to the hospital, so we can ignore the time it might take for the doctor or nurse to go from one venue to the other. Each outpatient clinic visit brings in \$20 in revenue. Each hospital room visit brings in \$15 in revenue. How many hospital room visits and outpatient clinic visits should the practice do to maximize revenue?

Making the Spreadsheet

Here is one good way to set up a spreadsheet for this problem. (There are other ways.)

	A	B	C
1		Clinic	Hospital
2	Visits	0	0
3			

First, identify what we can change: the number of clinic visits and the number of hospital visits. We have a column for each type of visit. The amounts for each type of visit go in row 2. I have put in 0's for the amounts, but any starting numbers are OK.

	A	B	C
1		Clinic	Hospital
2	Visits	0	0
3	Revenue per visit	20	15
4			

The revenue for each type of visit goes in row 3, under the Visits row.

To make the entire "Revenue per visit" label in A3 visible, I widened the A column. One way to do that is to click on the border between the A and B columns and mouse-drag the border to the right.

In column D, in row 3, I put the total revenue, which is $20 \times (\text{Clinic visits}) + 15 \times (\text{Hospital visits})$

	A	B	C	D
1		Clinic	Hospital	Total
2	Visits	0	0	
3	Revenue per visit	20	15	0
4				

In D3, I used the SUMPRODUCT function. It's the same as typing $=B2*B3+C2*C3$. Either multiplies the number of clinic visits (B2) by the revenue per clinic visit (B3) and adds that to the number of hospital visits (C3) times the

revenue per hospital visit (C3).

The SUMPRODUCT function in Excel is like vector dot multiplication. The general form is =SUMPRODUCT(First Range , Second Range). It means: Take the first cell in the first range, multiply by the first cell in the second range; then take the second cell in the first range, multiply that by the second cell in the second range; and so forth, multiplying each pair of corresponding numbers. Then add all the products up.

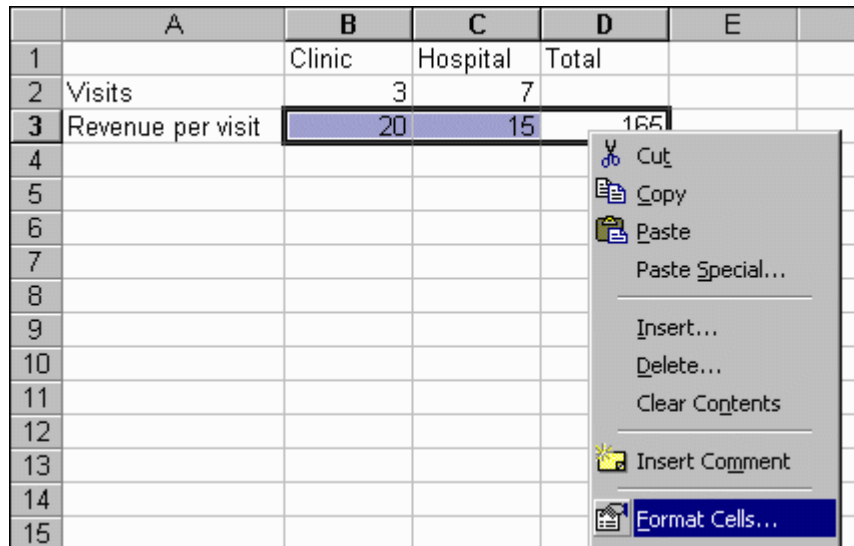
The SUMPRODUCT formula is overkill in this example. However, if there were more than two columns of visit types, the SUMPRODUCT formula would be shorter, less error-prone, and easier to extend.

To verify that the formula in D3 is working properly, change the visits to 3 and 7. You should get 165 in D3.

To show that the numbers in the Revenue row are dollars, change the numeric format to Currency. Here is how:

Select the revenue row of cells, right-clicked (Ctrl+click should work on a Mac) to bring up the context menu. From there, select Format Cells This brings up the Format Cells dialog box.

Use the Number tab in the Format Cells dialog box. There you can change the Number format to Currency.



Here is the result of the change to Currency format.

	A	B	C	D
1		Clinic	Hospital	Total
2	Visits	3	7	
3	Revenue per visit	\$20.00	\$15.00	\$165.00

The next fact to put in the spreadsheet is how much doctor time we are using, calculated

from the number of each type of visit and how long each type of visit takes. We want the Doctor time total so we can tell if we are exceeding the 300 minutes limit.

	A	B	C	D
1		Clinic	Hospital	Total
2	Visits	3	7	
3	Revenue per visit	\$20.00	\$15.00	\$165.00
4	Doctor time per visit	10	20	170

In the 4th row I put the number of doctor-minutes each type of visit requires. I widened column A again to accommodate the text in the cell A4. Each clinic visit requires 10 doctor-minutes, so 10 goes in B4. Each hospital visit requires 20 doctor-

minutes, so 20 goes in C4.

Cell D4 is where I calculate the total number of doctor-minutes required to make the number of clinic and hospital visits in the 2nd row. The formula in D4 can be =SUMPRODUCT (B2 : C2 , B4 : C4) , or it can be =B2*B4+C2*C4 .

You can enter the formula in Cell D4 by copying from the cell above it, D3. First, go to D3. Add \$ signs to the formula there by editing the cell and putting \$ signs before each 2, so it looks like this: =SUMPRODUCT (B\$2 : C\$2 , B3 : C3) or =B\$2*B3+C\$2*C3 . Then copy that cell and paste to D4.

By the way, that formula is where the assumption comes in that we can neglect the time it takes the doctor to go from the hospital to the clinic or vice versa. Total doctor time is just doctor clinic time plus doctor hospital time.

	A	B	C	D
1		Clinic	Hospital	Total
2	Visits	3	7	
3	Revenue per visit	\$20.00	\$15.00	\$165.00
4	Doctor time per visit	10	20	170
5	Nurse time per visit	20	10	130

In the 5th row I put the number of nurse-minutes each type of visit requires. Each clinic visit requires 20 nurse-minutes, so 20 goes in B5. Each hospital visit requires 10 nurse-minutes, so 10 goes in C5..

Cell D5 has the total number of nurse-minutes required to make the number of clinic and hospital visits in the 2nd row. The formula in D5 can be =B2*B5+C2*C5, or it can be =SUMPRODUCT (B2 : C2 , B5 : C5) . D5 can be copied from D4, if you have the \$ signs in place as described above.

Using the Spreadsheet

We have put all the given information into our spreadsheet. Now we can start trying different numbers in the 2nd row. Our goal is to find the combination of clinic and hospital visits that makes the total revenue the greatest, while keeping both the doctor minutes and the nurse minutes at 300 or less.

To make it easier to not exceed the 300 minute limits, we can dress up the spreadsheet this way:

F4		=IF(D4>E4,"Too much!","OK")				
	A	B	C	D	E	F
1		Clinic	Hospital	Total	Limit	
2	Visits	3	7			
3	Revenue per visit	\$20.00	\$15.00	\$165.00		
4	Doctor time per visit	10	20	170	300	OK
5	Nurse time per visit	20	10	130	300	OK

I put the limiting numbers in column E, so we can see them. In column F, I put indicators of whether each limit is exceeded.

Cell F4 has =IF (D4>E4, "Too much!", "OK") .

The general form of the IF function is three items separated by commas: =IF(some condition that may be true or false , what goes in the cell if the condition is true , what goes in the cell if the condition is false)

Here, the “some condition that may be true or false” is $D4 > E4$. The “what goes in the cell if the condition is true” is “Too much!” because if D4 is bigger than E4, we have exceeded our doctor time limit. The “what goes in the cell if the condition is false” is “OK” because if D4 is not bigger than E4, we have not exceeded our doctor time limit.

F5 contains a similar IF function to tell us if the nurse time limit is exceeded. You can copy from F4 and paste to F5.

If you put in visits numbers that are too large, you will see something like this:

	A	B	C	D	E	F
1		Clinic	Hospital	Total	Limit	
2	Visits	15	7			
3	Revenue per visit	\$20.00	\$15.00	\$405.00		
4	Doctor time per visit	10	20	290	300	OK
5	Nurse time per visit	20	10	370	300	Too much!

We can't do 15 clinic visits and 7 hospital visits, because it would require more nurse time than we have.

Assignment 9

1. Implement the above spreadsheet and find the combination of visits that brings the most revenue without exceeding the time limits.

For full credit for problem 1, you must find the best solution. The answer checker will tell you if you have found the best answer.

2. Do the contest described on the following pages.

For full credit for problem 2, a good effort is needed. You do not have to win the contest to get an A.

Contest – Win a Valuable Prize!

You are the chief executive of General Motors. You must decide how many of each of your types of vehicle to build. This table shows what vehicles you can build and how much profit you make from each one. (Any resemblance between these numbers and the truth is purely coincidental.)

Vehicle	Unit Profit
Buick	\$600
Cadillac	\$900
Chevy	\$480
Saturn	\$520
Pontiac	\$480
GMC Truck	\$600

These vehicles are made from various combinations of six resources. The next table shows how much of each resource each vehicle requires. (Any resemblance between these numbers and the truth is purely unbelievable.)

	Buick	Cadillac	Chevy	Saturn	Pontiac	GMC
Steel	1	4	0	4	2	0
Wood	4	5	3	0	1	0
Plastic	0	3	8	0	1	0
Rubber	2	0	1	2	1	5
Glass	2	4	2	2	2	4
Paint	1	4	1	4	3	4

This third table shows how much of each resource you have to start.

Resource	Amount Available
Steel	80
Wood	116
Plastic	178
Rubber	105
Glass	136
Paint	124

Your job is to determine how many of each vehicle you should make to maximize your total profit. The student whose plan gives the most profit will win a valuable prize! BUT, you must do it by trial and error. DO NOT use linear programming methods such as are built in to Excel or Quattro Pro, if you wish to be eligible for the prize.

Submit your answer before or at the start of class on the due date given on the syllabus to be eligible for the prize.

The syllabus has a link to the file CONTEST.XLS. Download it. Open it. It should come up looking like this:

	A	B	C	D	E	F	G	H	I
1	Product:		Buick	Caddy	Chevy	Saturn	Pontiac	GMC	TOTAL
2	Quantity:		0	0	0	0	0	0	
3	Unit profit:		600	900	480	520	480	600	
4	Total profit:		0	0	0	0	0	0	0
5	-----								
6	Resources Start with	Required per unit of each product							Remain
7	-----								
8	Steel	80	1	4	0	4	2	0	80
9	Wood	116	4	5	3	0	1	0	116
10	Plastic	178	0	3	8	0	1	0	178
11	Rubber	105	2	0	1	2	1	5	105
12	Glass	136	2	4	2	2	2	4	136
13	Paint	124	1	4	1	4	3	4	124

Numbers in row 2 are how many of each type of vehicle that you would like to make. As you change those numbers, you will see how many of your resources get used and how much profit you make.

Plug in your trial numbers where the 0's are in cells C2 through H2. No negative numbers allowed. The spreadsheet will calculate how much profit you have (in cell I4), and how many resources remain (in cells I8:I13). All the Remain amounts must be 0 or bigger than 0.

Your objective is to find the combination of numbers in C2:H2 that gives the greatest value in I4 without making any of the values in I8:I13 negative.

If you are in the lab, be sure to save your file to your storage device. Don't leave your solution around for all your friends to copy!