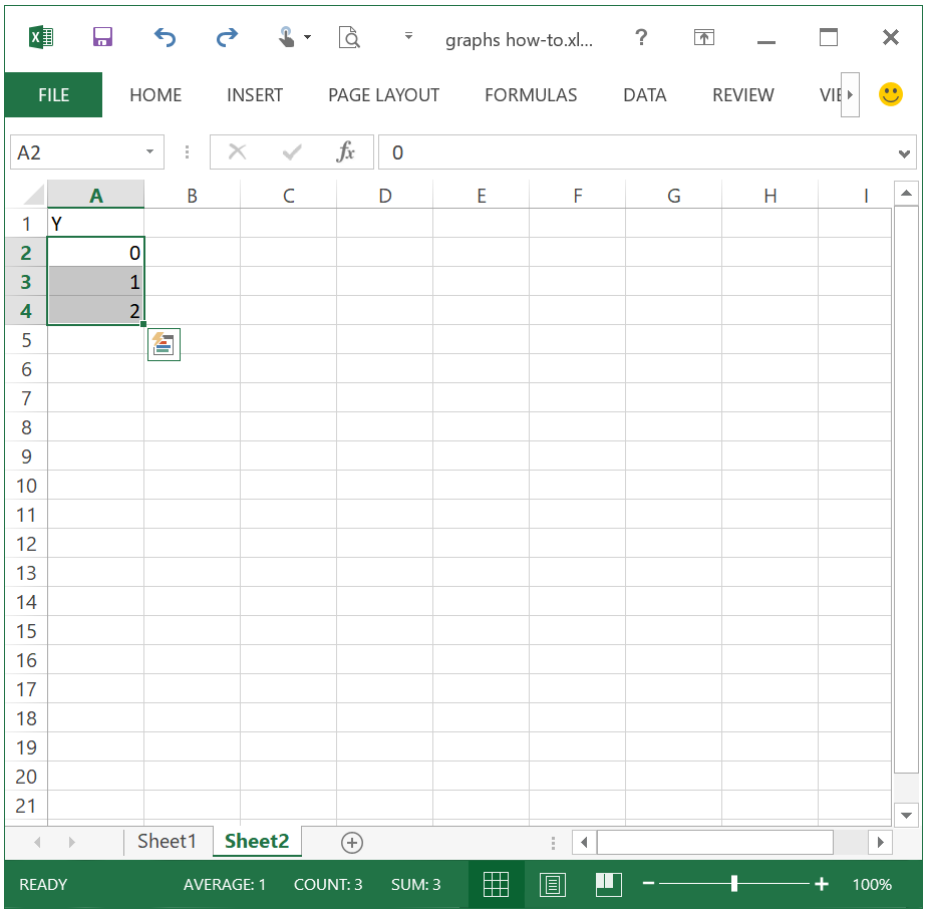
Formulae and Graphing in Excel

Professor Jacobson

The purpose of this document is to give helpful hints and tricks about how to do formulae and graphing in Excel. These are useful in lots of settings; I'm showing you applications of the methods to look at firm cost functions. All examples and specific details come from Excel on the PC in Windows 10; execution details differ on the Macintosh and on other versions of Excel, but the ideas are the same. This is not the only way to do any of these things; but it's the way I do it.

Formulae

You may want to see the relationship between two variables. Say you have some function *c* of variable *Y*. Say you know *Y* ranges from 0 up to larger numbers, but you think the range of interest to you is probably 0 to 20. The first thing to do is make a column of numbers with the variable name at the top. Note you can create a column of sequential numbers using the "fill" function by typing the first few numbers, selecting all of them, and then dragging down (in PC's, you drag from the lower-right corner of the cells when you have a black "plus"-shaped cursor). This will extend the pattern you've started (be it 1, 2, 3… or 10, 20, 30… or 0.1, 0.2, 0.3…).

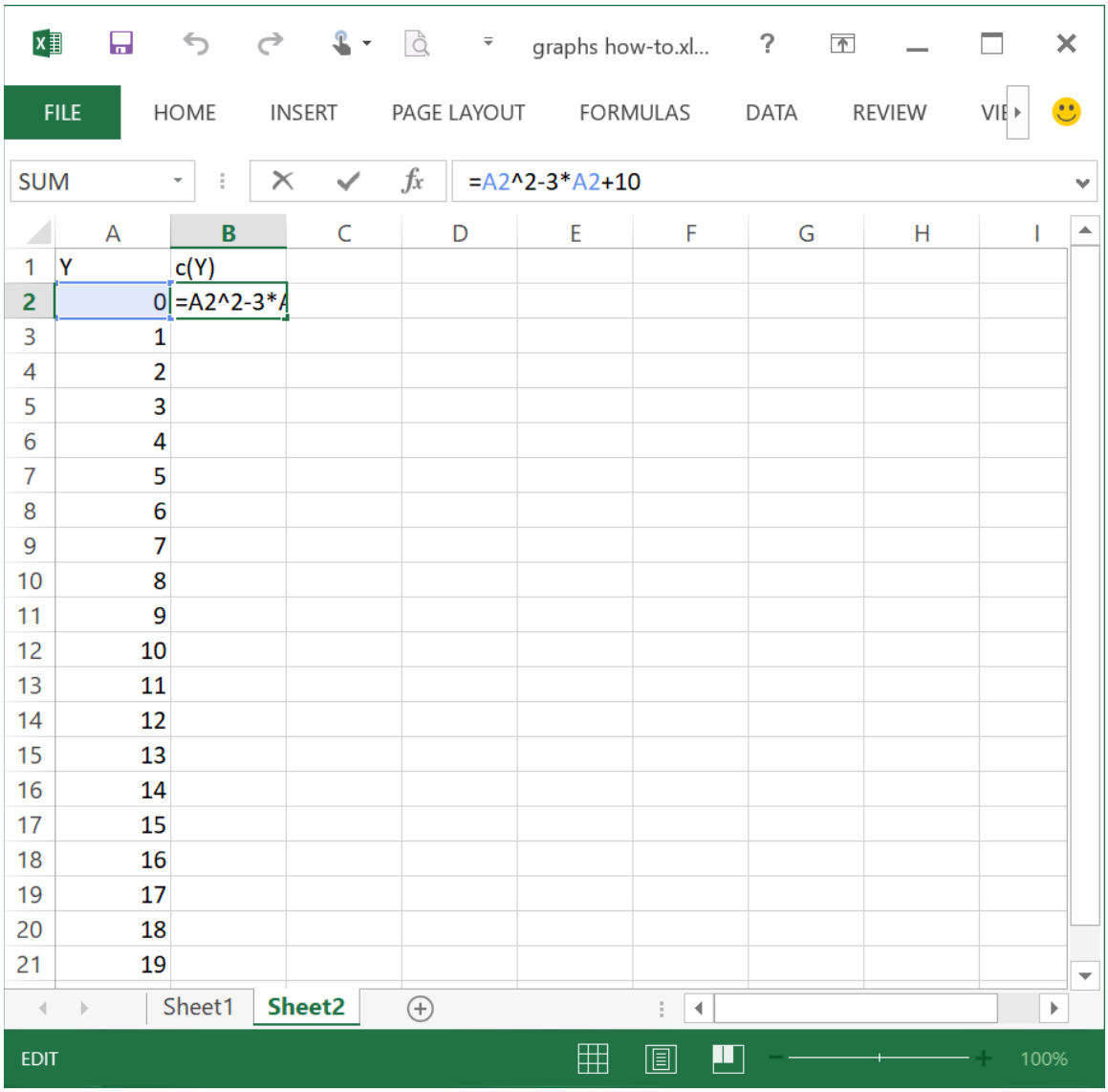


Next, make the next column hold numbers calculated from a formula that depends on your *Y*'s. In general, if you want to refer to value in another cell, you can simply include the relevant cell letter and number (either by typing them or by clicking on that cell). This creates a reference to that cell, like the "A2" in the image below.

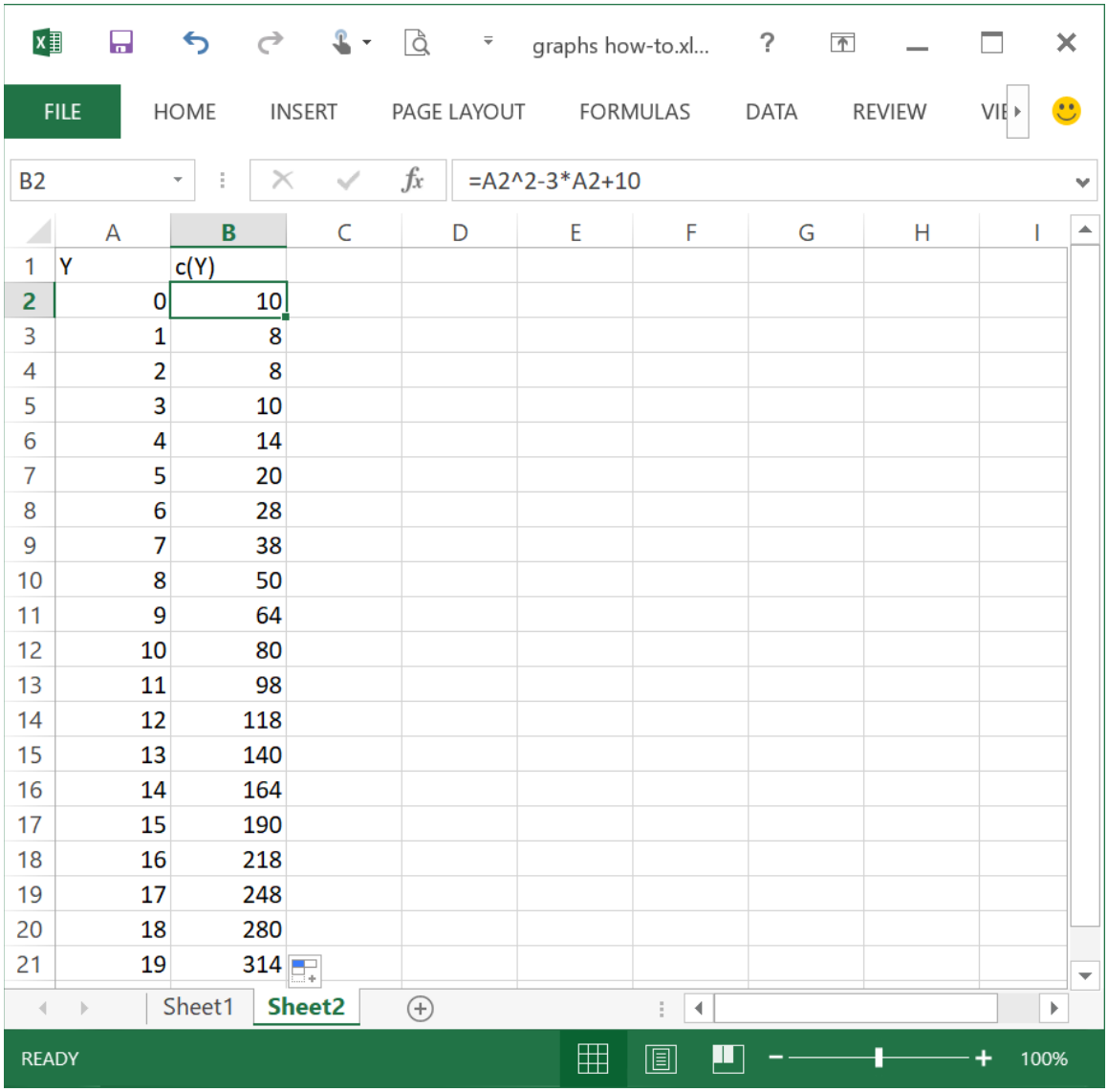
Here, I implement the formula:

$$c(Y) = Y^2 - 3Y + 10$$

Notice that in all of the places where *Y* is in the formula above, A2 shows up in the Excel formula.



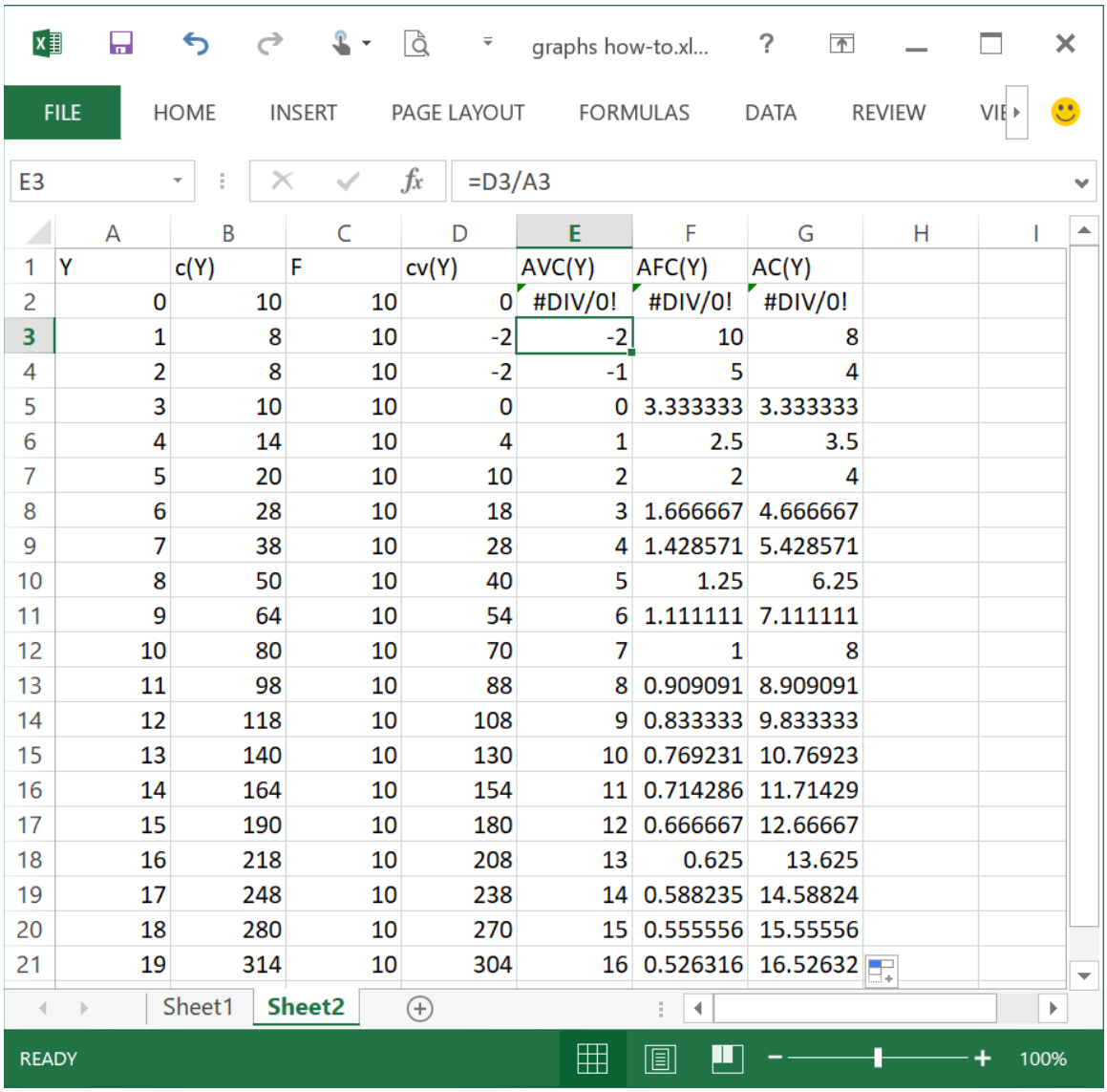
If you're doing this to make a plot, you'll probably make it so all the values in this function column (in this example, column B) are the values of $c(Y)$ for the value of Y (column A) in the same row. So again I'll drag that down to fill all cells in that column. This time, the pattern it's extending is the row number in the formula. Thus, filling down causes the cell reference to update dynamically from row to row, so if the formula in B2 was "=A2^2-3*A3+10", the formula in B3 will be "=A3^2-3*A3+10", and so on.[1]



	A	B
1	Y	c(Y)
2	0	10
3	1	8
4	2	8
5	3	10
6	4	14
7	5	20
8	6	28
9	7	38
10	8	50
11	9	64
12	10	80
13	11	98
14	12	118
15	13	140
16	14	164
17	15	190
18	16	218
19	17	248
20	18	280
21	19	314

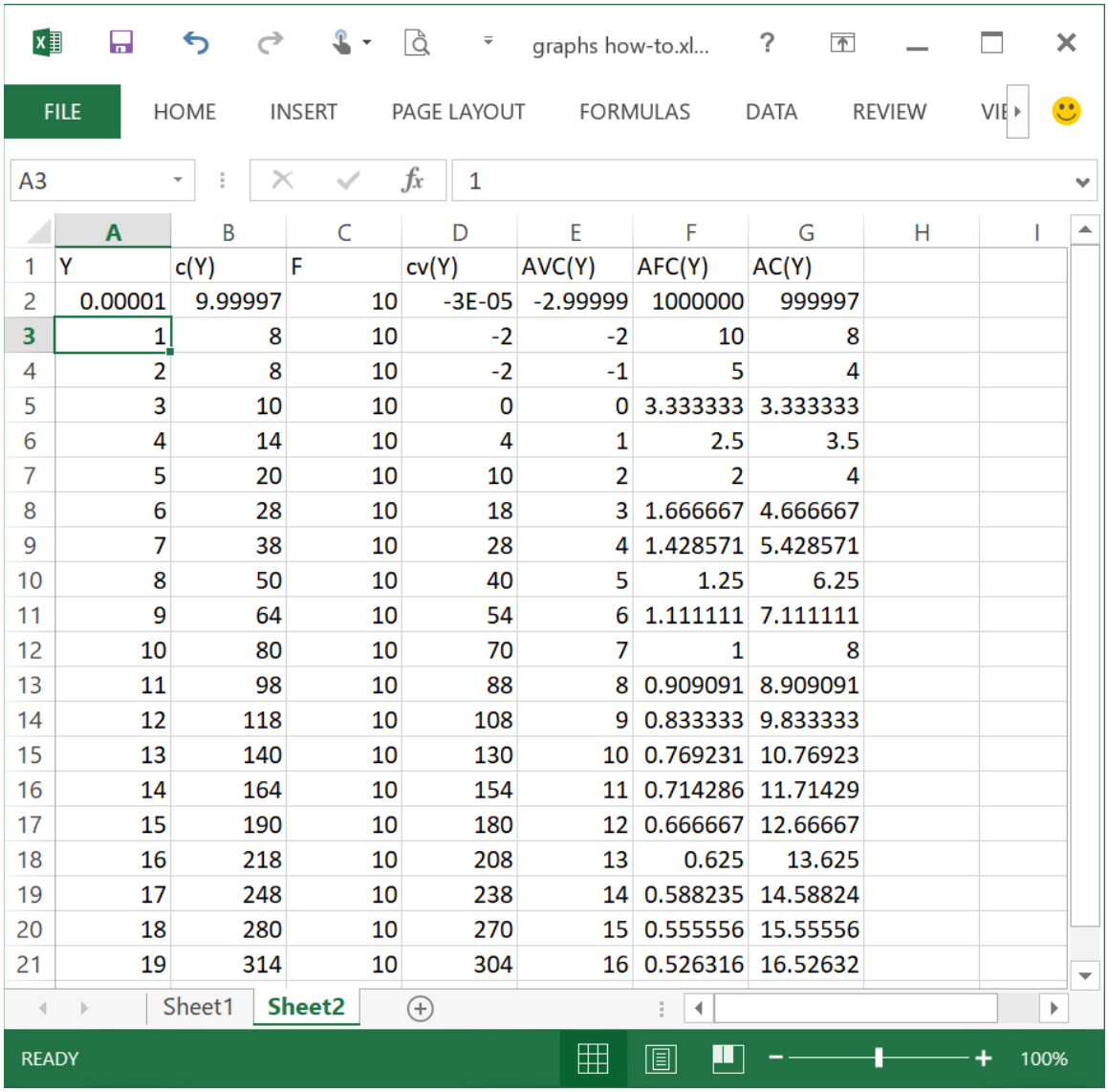
[1] If you don't want all of the cell references in a formula to fill (e.g. if you want to always refer to a specific parameter cell but still update the Y value as you drag down), that's when you use the $ to make it an "absolute reference" (as opposed to a "relative reference," i.e. relative to this cell's position). You can google how to do that.

Now let's add a few more functions. I want to make a fixed cost column that's 10 all the way down, and a variable cost column that is $c(Y)$ minus that, and I'll make some average cost columns as well.



	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0	10	10	0	#DIV/0!	#DIV/0!	#DIV/0!
3	1	8	10	-2	-2	10	8
4	2	8	10	-2	-1	5	4
5	3	10	10	0	0	3.333333	3.333333
6	4	14	10	4	1	2.5	3.5
7	5	20	10	10	2	2	4
8	6	28	10	18	3	1.666667	4.666667
9	7	38	10	28	4	1.428571	5.428571
10	8	50	10	40	5	1.25	6.25
11	9	64	10	54	6	1.111111	7.111111
12	10	80	10	70	7	1	8
13	11	98	10	88	8	0.909091	8.909091
14	12	118	10	108	9	0.833333	9.833333
15	13	140	10	130	10	0.769231	10.76923
16	14	164	10	154	11	0.714286	11.71429
17	15	190	10	180	12	0.666667	12.66667
18	16	218	10	208	13	0.625	13.625
19	17	248	10	238	14	0.588235	14.58824
20	18	280	10	270	15	0.555556	15.55556
21	19	314	10	304	16	0.526316	16.52632

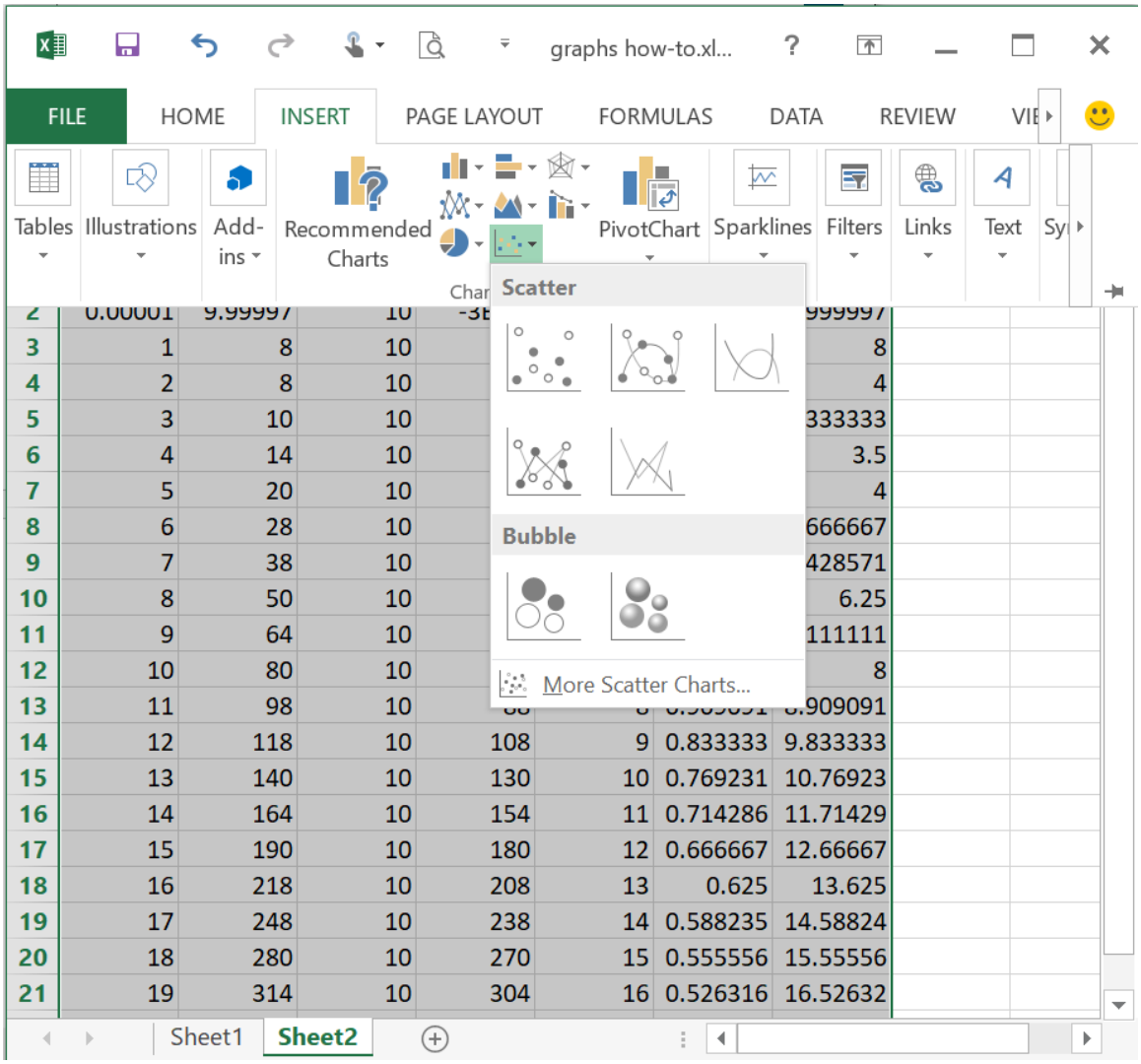
Note that I get a nasty "divided by zero" in the average cost columns for Y=0. In a way that doesn't matter, but it will make the plot look ugly around zero (which will make the axes explode so you can't properly look at the curves). Therefore, I want to change Y=0 to Y=0.00001 (or any value near zero). I'll do that manually just by typing that number in. This is kind of an ad hoc thing and I may be the only one who does it this way, but it's one of the simplest ways to keep the axes and curves reasonable looking.



	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0.00001	9.99997	10	-3E-05	-2.99999	1000000	999997
3	1	8	10	-2	-2	10	8
4	2	8	10	-2	-1	5	4
5	3	10	10	0	0	3.333333	3.333333
6	4	14	10	4	1	2.5	3.5
7	5	20	10	10	2	2	4
8	6	28	10	18	3	1.666667	4.666667
9	7	38	10	28	4	1.428571	5.428571
10	8	50	10	40	5	1.25	6.25
11	9	64	10	54	6	1.111111	7.111111
12	10	80	10	70	7	1	8
13	11	98	10	88	8	0.909091	8.909091
14	12	118	10	108	9	0.833333	9.833333
15	13	140	10	130	10	0.769231	10.76923
16	14	164	10	154	11	0.714286	11.71429
17	15	190	10	180	12	0.666667	12.66667
18	16	218	10	208	13	0.625	13.625
19	17	248	10	238	14	0.588235	14.58824
20	18	280	10	270	15	0.555556	15.55556
21	19	314	10	304	16	0.526316	16.52632

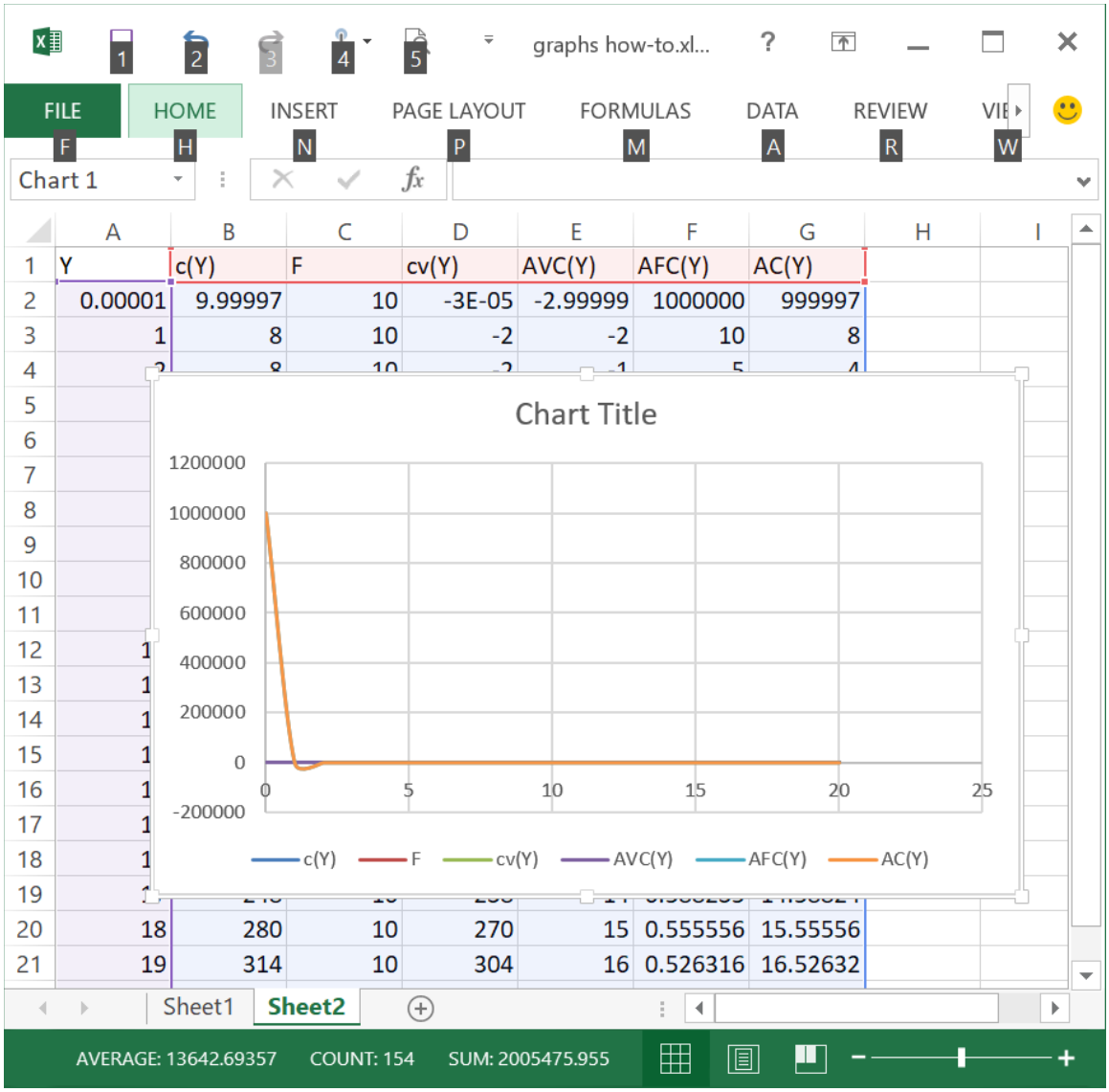
Making Plots

Now I want to plot everything all together. This is really easy. I just select all of the columns. Then I go to the “Insert” menu tab in the ribbon at the top of the screen. In the “Charts” section of the menus at the top, I pull down the “Scatter” option.



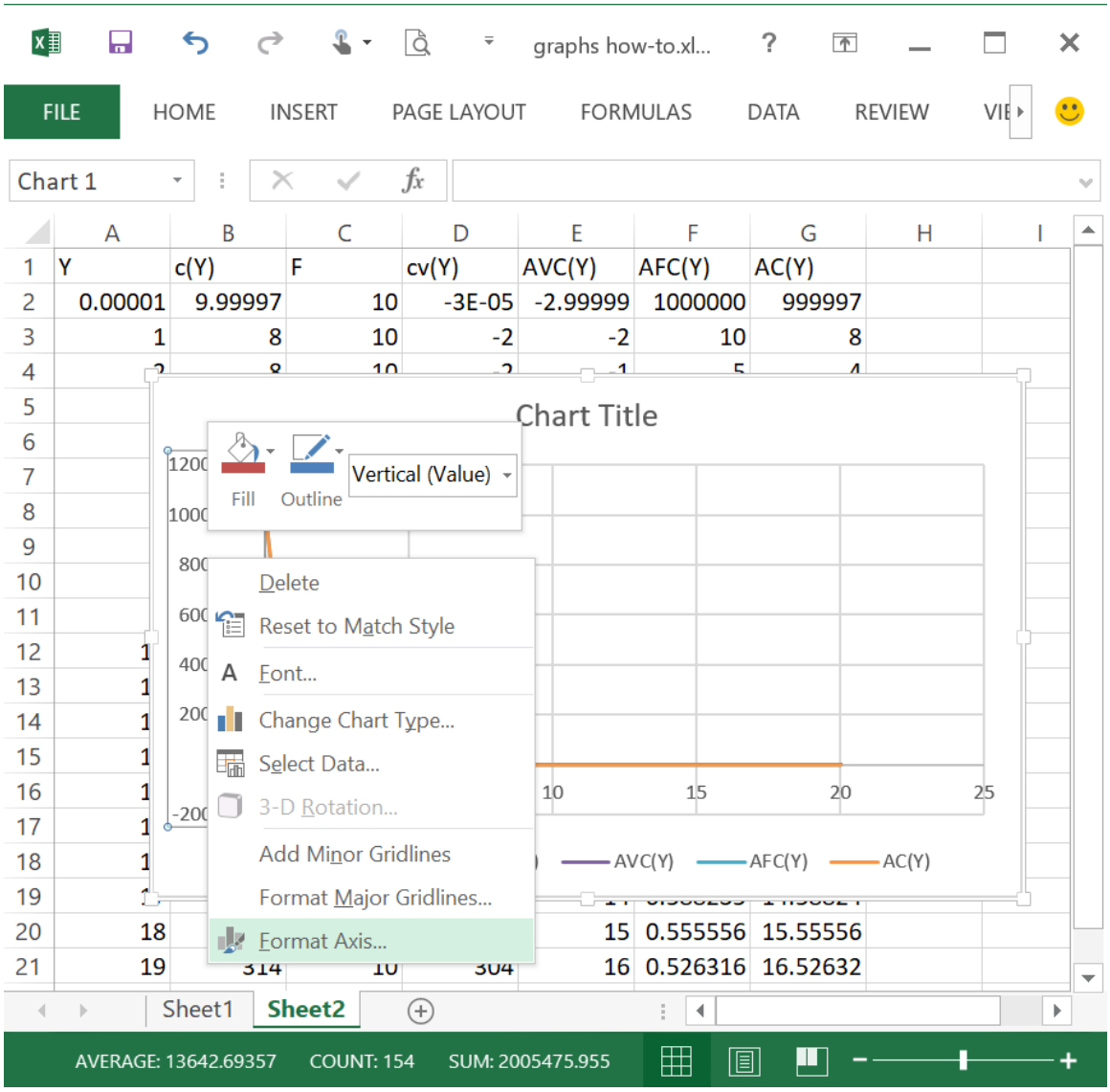
2	0.00001	9.99997	10	-3E			999997	
3	1	8	10				8	
4	2	8	10				4	
5	3	10	10				333333	
6	4	14	10				3.5	
7	5	20	10				4	
8	6	28	10				666667	
9	7	38	10				428571	
10	8	50	10				6.25	
11	9	64	10				111111	
12	10	80	10				8	
13	11	98	10				8.909091	
14	12	118	10	108	9	0.833333	9.833333	
15	13	140	10	130	10	0.769231	10.76923	
16	14	164	10	154	11	0.714286	11.71429	
17	15	190	10	180	12	0.666667	12.66667	
18	16	218	10	208	13	0.625	13.625	
19	17	248	10	238	14	0.588235	14.58824	
20	18	280	10	270	15	0.555556	15.55556	
21	19	314	10	304	16	0.526316	16.52632	

For this plot, I prefer “Scatter with smooth lines”. And this gives me a plot!



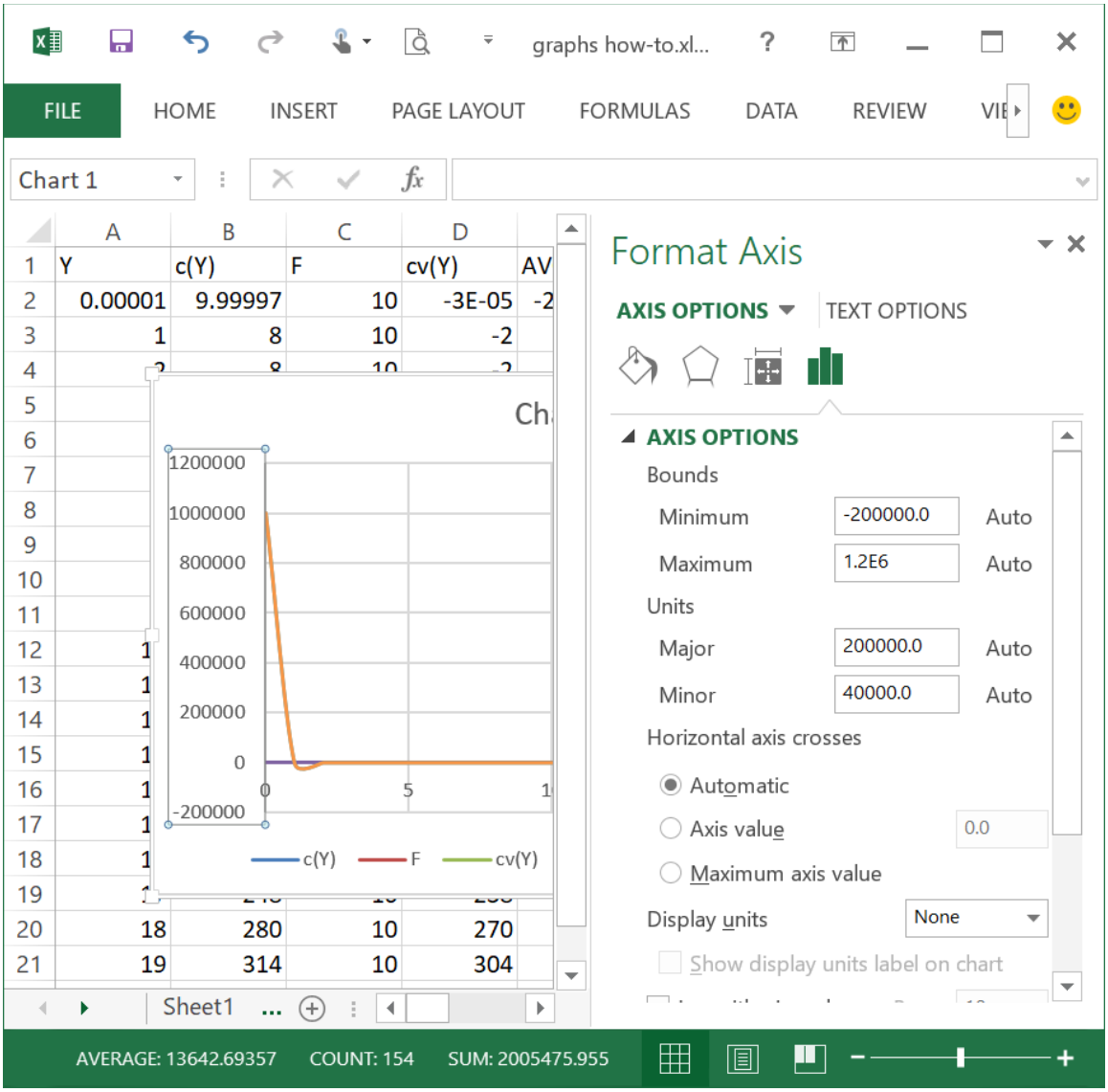
	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0.00001	9.99997	10	-3E-05	-2.99999	1000000	999997
3	1	8	10	-2	-2	10	8
20	18	280	10	270	15	0.555556	15.55556
21	19	314	10	304	16	0.526316	16.52632

Ick. What's wrong? The problem is simply that the axes are not very helpful—the vertical scale in particular is so zoomed out we can't see anything, and that's because Excel automatically scales the axes based on the values being plotted (and those average costs near zero get very large). This will look much nicer if I rescale the axes. How do I do that? I right-click on the vertical axis first, and choose "Format Axis".

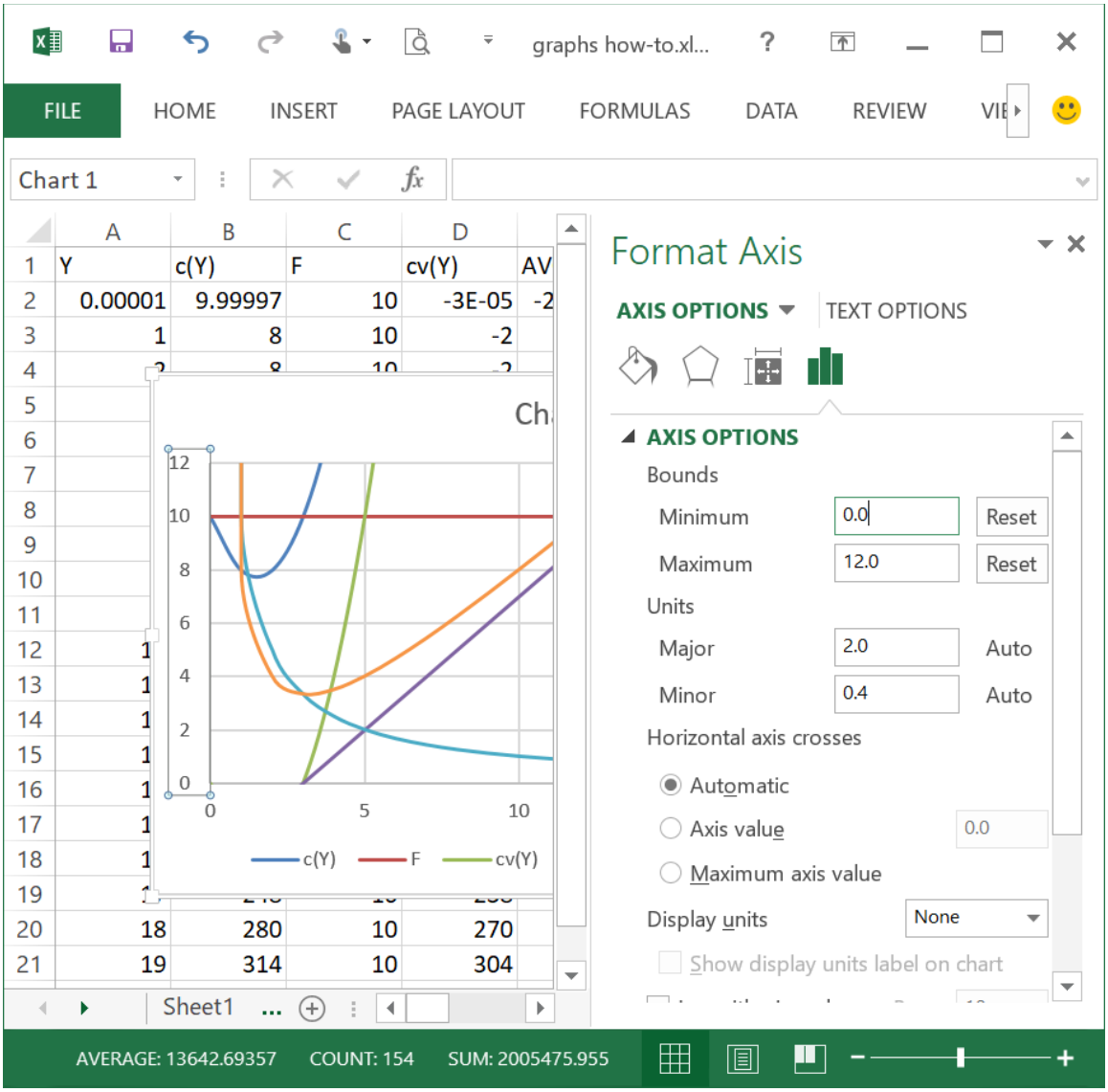


	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0.00001	9.99997	10	-3E-05	-2.99999	1000000	999997
3	1	8	10	-2	-2	10	8
20	18				15	0.555556	15.55556
21	19				16	0.526316	16.52632

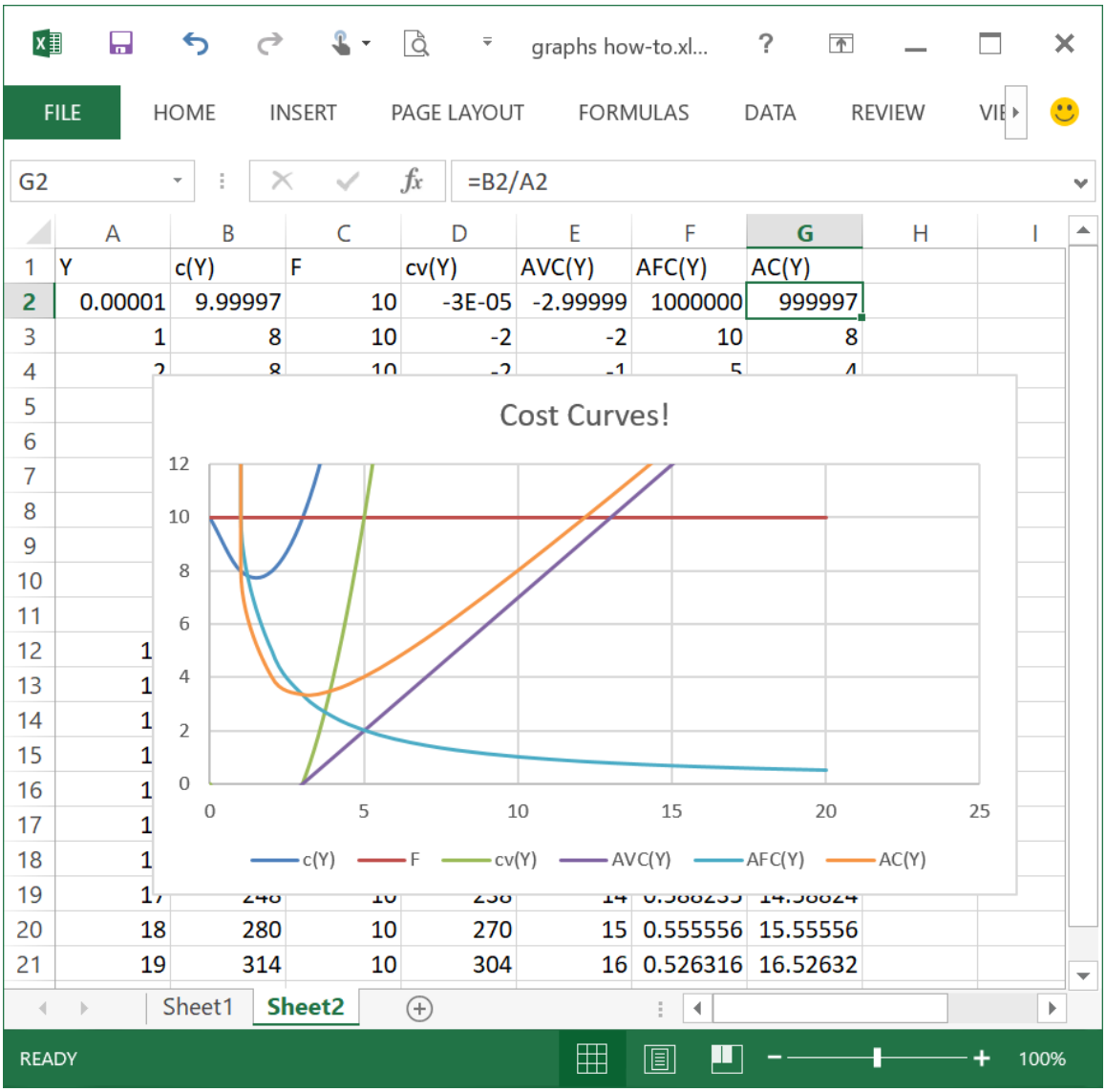
This brings up the following menu panel:



Now I'm going to changes the Axis Minimum and Maximum to look more sensible.

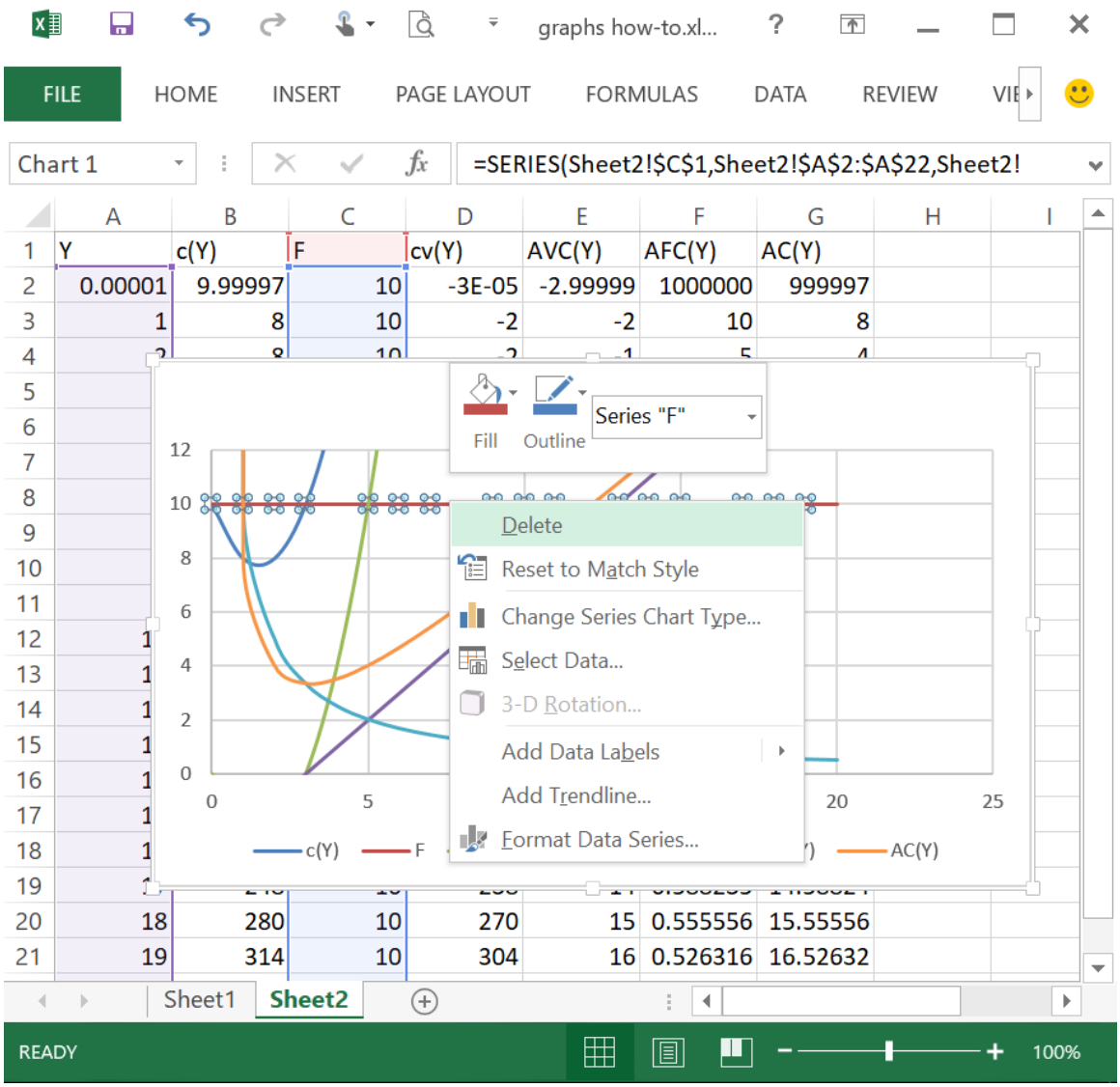


And voila! Now I have a graph with a nice set of curves. Notice the legend below the graph was automatically created based on the names at the top of each column. I also manually edited the chart title by clicking in it and typing new text.



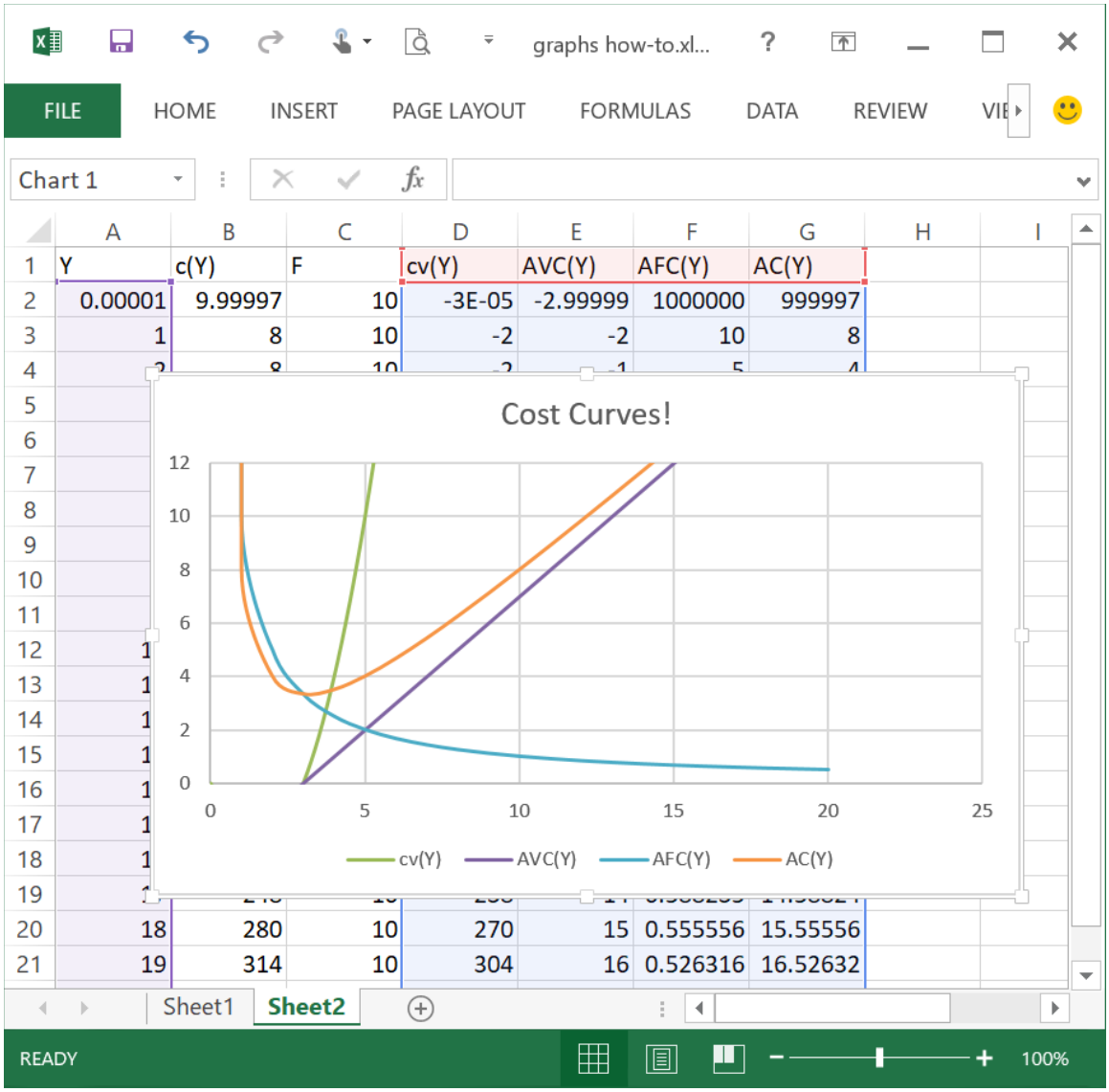
	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0.00001	9.99997	10	-3E-05	-2.99999	1000000	999997
3	1	8	10	-2	-2	10	8
4	2	8	10	-2	-1	5	4
5							
6							
7							
8							
9							
10							
11							
12	1						
13	1						
14	1						
15	1						
16	1						
17	1						
18	1						
19	17	248	10	238	14	0.588235	14.58824
20	18	280	10	270	15	0.555556	15.55556
21	19	314	10	304	16	0.526316	16.52632

We can also remove some lines from this graph to make it less cluttered. There are many ways to do this, but one is to right-click on a data series and choose “Delete”:



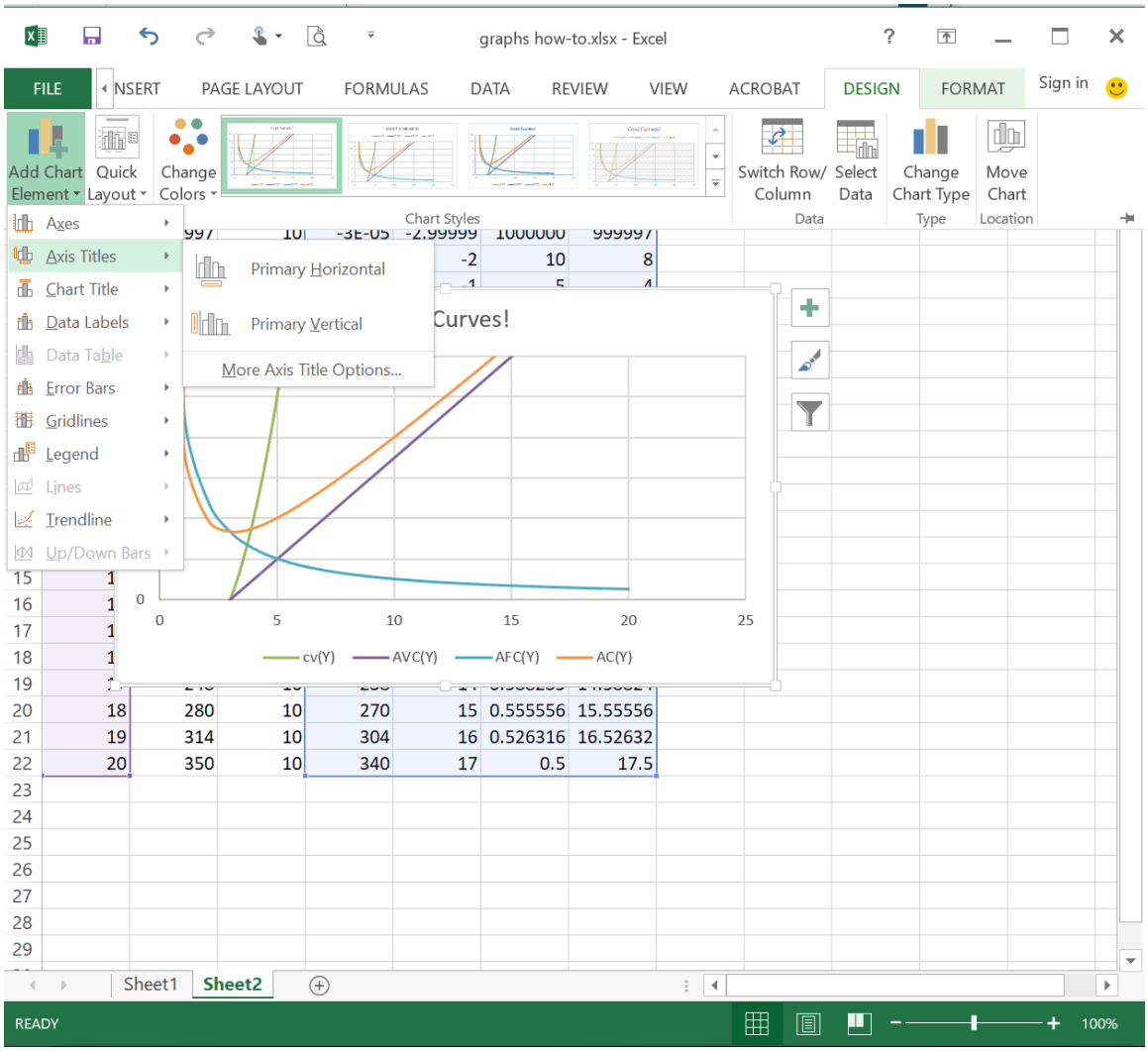
	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0.00001	9.99997	10	-3E-05	-2.99999	1000000	999997
3	1	8	10	-2	-2	10	8
20	18	280	10	270	15	0.555556	15.55556
21	19	314	10	304	16	0.526316	16.52632

And then the plot looks much nicer!



	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0.00001	9.99997	10	-3E-05	-2.99999	1000000	999997
3	1	8	10	-2	-2	10	8
4	2	8	10	-2	-1	5	4
5							
6							
7							
8							
9							
10							
11							
12	11						
13	12						
14	13						
15	14						
16	15						
17	16						
18	17						
19	18						
20	18	280	10	270	15	0.555556	15.55556
21	19	314	10	304	16	0.526316	16.52632

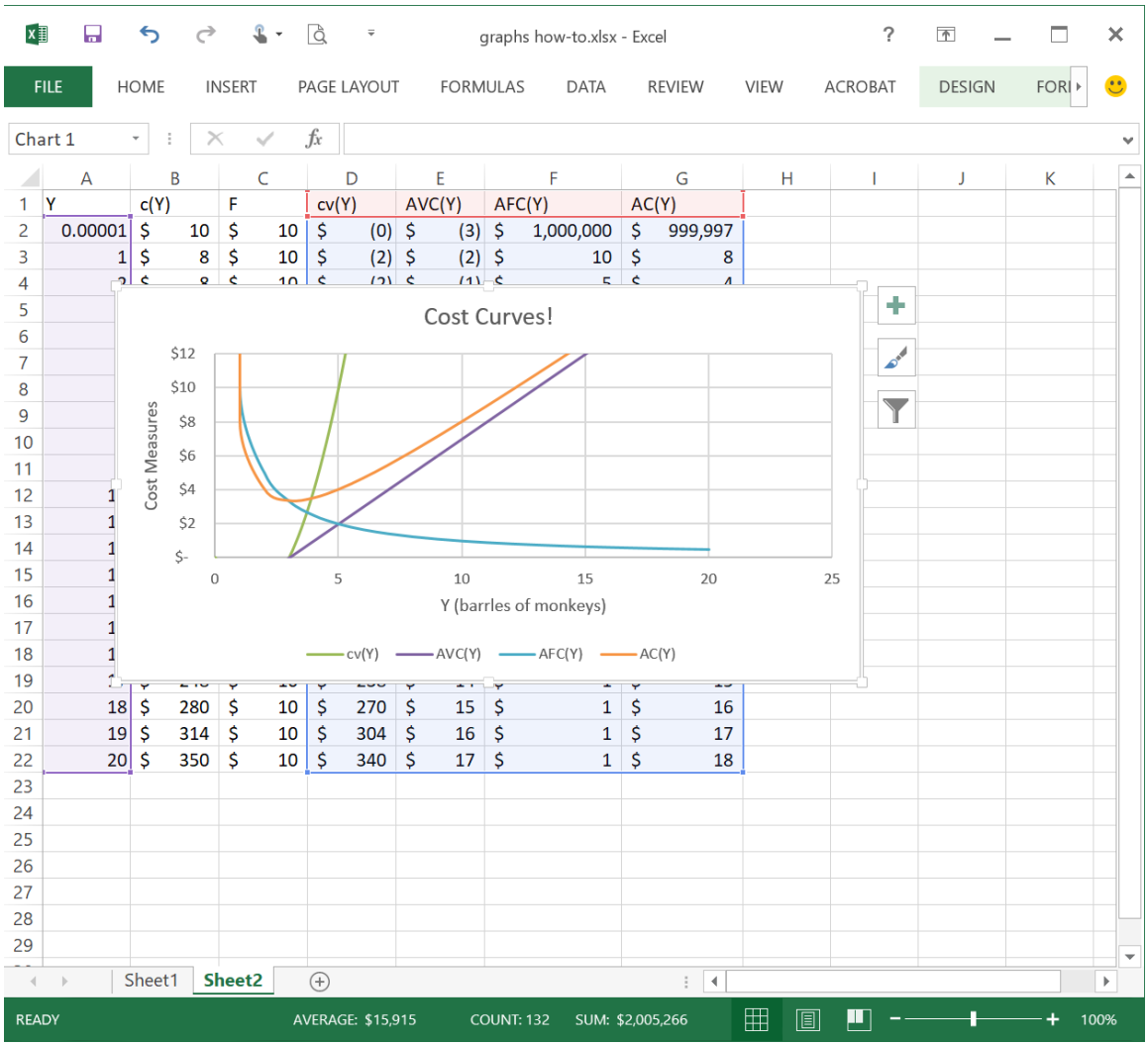
Finally, wouldn't it be nice if the axes were properly labeled? You can do that easily in Excel, too. Make sure the plot is selected, then click on Design in the ribbon (you may have to scroll to find it), then click "Add Chart Element" and choose Axis Titles.



Choose Primary Horizontal Axis Title, and a text box will appear under the axis and you can just select that text and replace it with something appropriate, like the variable name and description. Then choose Primary Vertical Axis Title, and the same will happen again but for the vertical axis.

A final flourish that's nice: make it so dollar figures show up as such in the graph. Select all of the cost columns and change their format to a dollar format. (You can do this before you make the graph, of course.) There are several ways to do this; the easiest is probably to be in the Home tab, and within the Number block click the $ (dollar sign) button. It might give you two places to the right of the decimal that you don't want; you can get rid of those by, within the same Number block in the Home tab, clicking the "reduce decimal" button (with an arrow and a .0 and a .00).

And voila!



	A	B	C	D	E	F	G
1	Y	c(Y)	F	cv(Y)	AVC(Y)	AFC(Y)	AC(Y)
2	0.00001	$ 10	$ 10	$ (0)	$ (3)	$ 1,000,000	$ 999,997
3	1	$ 8	$ 10	$ (2)	$ (2)	$ 10	$ 8
20	18	$ 280	$ 10	$ 270	$ 15	$ 1	$ 16
21	19	$ 314	$ 10	$ 304	$ 16	$ 1	$ 17
22	20	$ 350	$ 10	$ 340	$ 17	$ 1	$ 18

The plot can be selected and copied and pasted into other documents, or printed directly from Excel, or any number of other things.

(Are you bothered by the fact that the orange line appears straight vertical at Y=1? It happens because the slope between Y=0.0001 and Y=1 is really steep, because it goes from $8 to almost $1 million. You could fix that by changing the first Y to something bigger like 0.1, or by adding more rows between Y=0.00001 and Y=1 – this latter way will smooth it out best.)