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Useful Excel Array Formulas and Range Functions

by Rick Hesse, Feature Editor

Excel has a set of array formulas and range functions that may not be known by many users which can be intimidating but very useful. The array functions are recognized by the curly brackets surrounding their formulas. Users may be familiar with these from One-way and Two-Way Data Tables, which allow users to do "what-if" analysis for one or two parameters. The range functions use common Excel functions in a range.

Frequency Function

The FREQUENCY function is an Excel array function, and the template shown in Figure 1 allows up to 160 data values in cells D22:K41 to be classified into categories or bins. In this case, the data are ages of 80 employees of a company. The entire range from C7:C18 must first be highlighted and then type:

=FREQUENCY
($D$22:$K$41,A7:A18)

Then hold the <Shift>+<Ctrl> keys down and then press <Enter>. When you enter an array formula, Microsoft Excel automatically inserts the formula between { } (braces). When you click inside a cell containing braces, they disappear, and you are not allowed to delete just a single cell in the array.

The data range is D22:K41, while the bins for the range for frequency is A7:A18. The first bin (C7) counts all the data values < 15, and there should be no values for that bin. The second bin (C8) counts the number of data values greater than 15 and < 20, and the last bin (C18) counts the number of values greater than 65 and < 70. The template with column graph is shown in Figure 1.

Row 4 shows 11 measurements of the data, and of special interest might be the calculation of the mean from the frequency data, which should approximate the actual mean. It uses the SUMPRODUCT formula for the counts times the midpoint values.

B4: SUMPRODUCT
(B8:B18,C8:C18)/C4

Because the array function is live (like a data table), we can change the values of the frequency bins and increase in steps of 10 years instead of five, as shown in Figure 2. Then, if we click on the column graph, the graph data is outlined, and we can grab the bottom right corner and drag it up to the first nonzero value and resize the graph. Note that the Frequency Average has changed from 35.563 to 35.000 and the true average remains 36.013.

The new graph then looks as shown in Figure 3. You now have a template that can give a frequency table and graph of up to 150 data points using up to 11 equal-sized bins (you need to make sure they are equal sized). This is an improvement on Excel's Data Analysis Tool because the data is allowed to be live and not restricted to one column.

Transpose Array Function

The TRANSPOSE function is a very handy array function that will transpose data from rows to columns, and vice versa. It is a live function, so that if the original data is changed (values, labels), the data is immediately transposed on the spreadsheet. There are times when it is impossible to get the correct orientation for data. Let us look at a simple example involving a 3-state Markov process, with the transition matrix and first five periods, as shown in Figure 4. The transition matrix is in cells B5:D7, and the initial conditions

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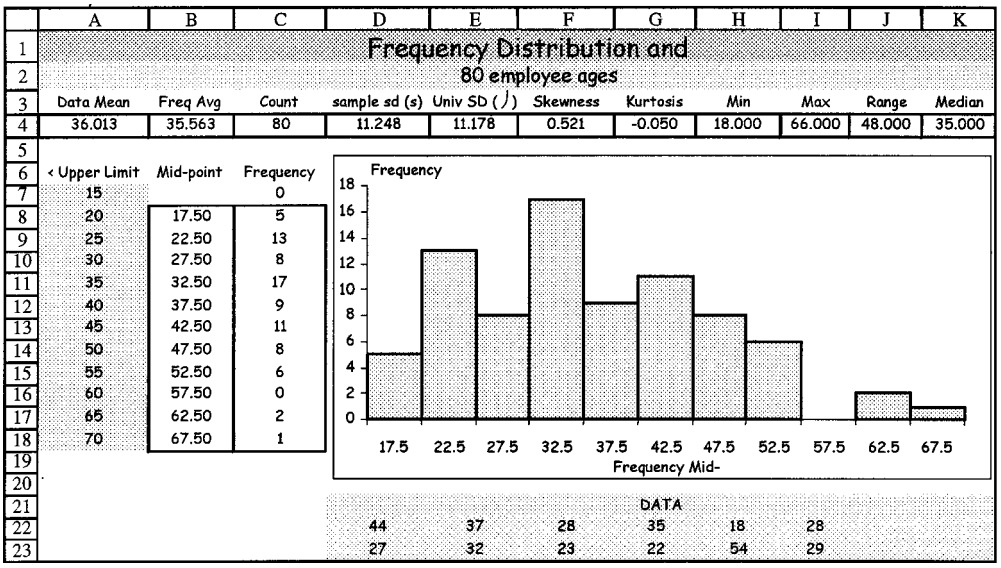

Figure 1: Frequency table and graph.

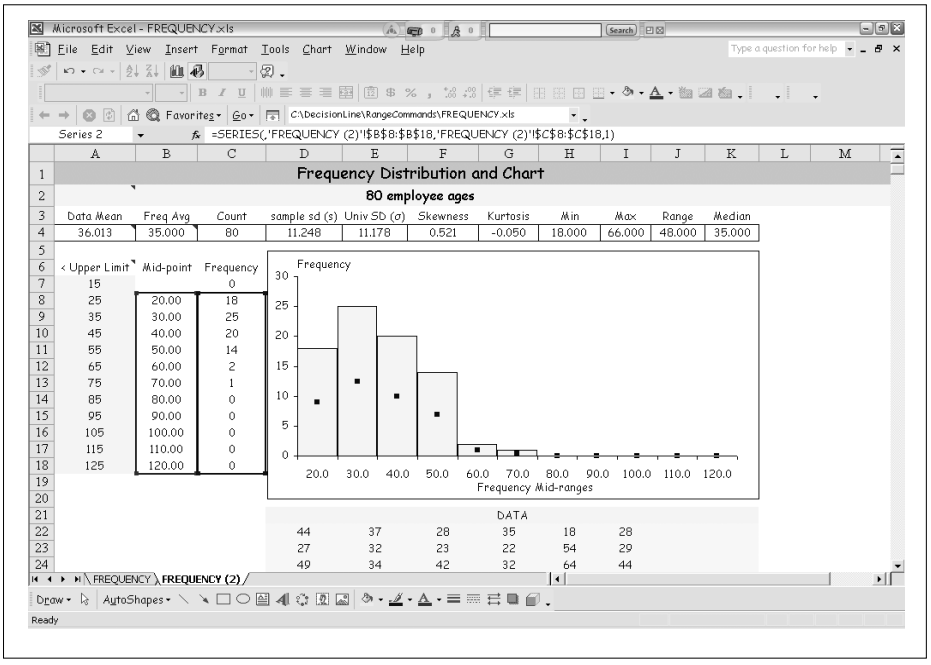

Figure 2: Changing bin sizes.

of market share are in B10:D10. The annual brand loyalty probabilities are on the major diagonal, and the brand switching probabilities are off the diagonal (the probability of switching from Nokia to Ericsson the next year is 2.2%).

The labels for the three digital cell phone manufacturers are typed into cells B4:D4, and then cells A5:A7 are highlighted and the following formula is typed: =TRANSPOSE(B4:D4). Then hold the <Shift>+<Ctrl> keys down and press <Enter>. The labels in row 4 are transposed to the column A. This array function works for the range A5:A7 and will not allow just one cell (like A5) to be deleted.

To do the calculations for years 1 → 10, it would be nice if Excel would allow the SUMPRODUCT function to have cell ranges with different orientation, so that SUMPRODUCT(B$5:B$7, $B10:$D10) in B11 would compute Year1 market share for Nokia, and then could be copied over and down. But Excel will give a message #VALUE!, meaning the formula cannot be evaluated. Frontline Systems, which provides the Educational Premium Solver with many texts that use the Excel Solver, also supplies a revised SUM- PRODUCT add-in which would allow different orientation. I don't give it to my students for the reason that when they share templates at work, most people don't have this add-in and then the template won't work. Of course, a solution could be to reorient the transition table (matrix), but since it reads better as FROM → TO, I wanted to keep that orientation. Another solution is to write the gruesome formula:

B11:=B$5*$B10+B$6*$C10
+B$7*$D10 and drag
over to D11 and down.

However, one of my students, Elizabeth Cousain, found the TRANSPOSE function in Excel and figured out how

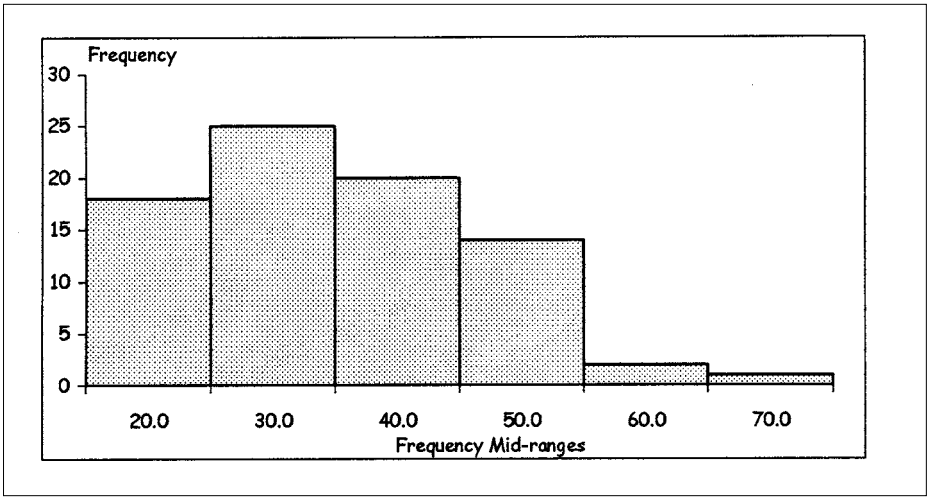

Figure 3: Resized graph.

	A	B	C	D	E
1	MARKOV BRAND SWITCHING MODEL				
2	CELL				
3		Cell Phone Manufacturer			
4	FROM--> TO	Nokia	Ericsson	Motorola	
5	Nokia	87.5%	2.2%	10.3%	
6	Ericsson	11.8%	73.7%	14.5%	
7	Motorola	15.9%	3.8%	80.3%	
8					
9	Year	Nokia	Ericsson	Motorola	TOTAL
10	0	45.0%	15.0%	40.0%	100.0%
11	1	47.5%	13.6%	38.9%	
12	2	49.3%	12.6%	38.1%	
13	3	50.7%	11.8%	37.5%	
14	4	51.7%	11.3%	37.0%	
15	5	52.4%	10.9%	36.7%	

Figure 4: Markov brand switching model.

	A	B	C	D	E	F	G
1	Group	Hmwk	Test1	Test2	Cases	Semester	Rank
2	Excelists	91.8%	90.8%	95.3%	86.0%	92.4%	1
3	Optimists	82.3%	85.0%	87.5%	82.0%	85.8%	4
4	Quantinators	93.9%	86.3%	83.7%	100.0%	87.6%	2
5	Spreadheads	84.1%	84.7%	86.3%	100.0%	87.1%	3

Figure 5: Summary grade sheet by group.

to make it work as an array function for this situation, as shown below:

```
B11:=SUMPRODUCT
     (B$5:B$7,TRANSPOSE
      ($B10:$D10))
```

Then hold the <Shift>+<Ctrl> keys down and then press <Enter>.

You can then copy B11 over to C11:D11 and then copy B11:D11 down as many rows as you want. After year 13, steady state is achieved (to 3 decimals). Since this array formula was written in one cell, you can erase any single cell or group of cells.

Range Functions

A former MBA student e-mailed me asking if there was a way to pull out the average for certain items in an unsorted list, and I could not figure it out. About two days later he emailed with the solution using the SUMIF and COUNTIF functions to determine the average of a range of numbers in one column that match a criteria in another column. I use this for my grade book to show the group averages on tests, cases, and homework as an incentive and friendly competition in my MBA classes. Shown in Figure 5 is the worksheet Totals which gets data from the worksheet Grades (Figure 6).

Cell B2 on the Totals worksheet illustrates these two range commands.

```
B2:=SUMIF(Grades!$A$4:$A
    $17,Totals!$A2,Grades!C$4:$C
    $17)/COUNTIF(Grades!$A$4:
     $A $17,Totals!$A2) and copied
     to B2:F5.
```

SUMIF(Range1, criterion, Range2) looks at the list in Range1 (Group Names on sheet Grades shown in FIGURE 6) that match the criterion (Group Name on the Total sheet) and sums up the corresponding homework scores in Range2 on the Grades sheet. This is then divided by the number of group members in the group Excelists to determine their homework average of 91.8 percent using the COUNTIF formula. The great thing about using this function is that it works between spreadsheets within the workbook, the list

	A	B	C	D	E	F	G
1				Worst	Best		
2		MBA 656	10%	35%	45%	10%	
3	Group Name	Student	Hmwk	Test1	Test2	Case	SEM
4	Quantinators	Adriano	90.3%	81.0%	84.0%	100%	85.2%
5	Excelists	Brian	89.9%	92.0%	93.0%	86%	91.6%
6	Excelists	Jose	95.4%	94.5%	99.0%	86%	95.8%
7	Spreadheads	Kavita	83.2%	90.0%	84.0%	100%	88.2%
8	Optimists	Mark	82.1%	80.0%	89.0%	82%	84.5%
9	Spreadheads	Monica	82.9%	79.0%	81.0%	100%	82.4%
10	Spreadheads	Rachelle	86.2%	85.0%	94.0%	100%	90.7%
11	Optimists	Sara	82.4%	84.0%	93.0%	82%	87.7%
12	Optimists	Scott	82.0%	88.0%	84.0%	82%	85.4%
13	Excelists	Sol	93.9%	89.0%	96.0%	86%	92.3%
14	Quantinators	Sophala	91.2%	82.0%	76.0%	100%	82.6%
15	Quantinators	Sylvia	100.0%	96.0%	91.0%	100%	95.1%
16	Excelists	Wade	88.1%	87.5%	93.0%	86%	89.9%
17	Optimists	Wren	82.8%	88.0%	84.0%	82%	85.5%

Figure 6: Grade sheet by group.

doesn't have to be sorted by Group Name, and the individual scores are kept confidential when showing the group averages.

Using these functions also averts having to use the more clumsy DATABASE functions for lists (DAVERAGE) or Pivot Tables. I have used SUMIF and COUNTIF formulas before for simpler situations, but with just two arguments rather than three. For instance, =COUNTIF(A4:A17,"Quantinators") returns the value 3 for the number of students in that group.

Conclusion

The functions demonstrated in this short tutorial should open up some new vistas for students as they apply spreadsheets to their jobs and companies. As always, the Excel file for this column is on the *Decision Line* website. ■

Related Link

Excel file for this column at http://www.decisionsciences.org/DecisionLine/Vol35/35_5/35_5classroom.xls

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serves that successful deans have the attributes of passion, the ability to create a culture for success, willingness to risk failure, patience, trust, leading by example, and vision.

Professor Varun Grover, Clemson University, provides a preliminary model for examining doctoral success. He describes the case of a student who did not have great GMAT scores but was eventually admitted to the doctoral program without financial aid only because a faculty member had "good feelings" about the candidate. It turned out that this student became one of the best in the program and graduated to become a contributing member of the academic community. He believes that motivation and competency, together with good program management abilities, are likely to be key ingredients for doctoral success.

Professor Miranda Lam, Salem State College, reviews several texts on financial modeling, a critical component of the finance curriculum in many schools. The reviewed books vary greatly in style and pedagogical approach.

I look forward to seeing you in Boston in a few weeks! ■