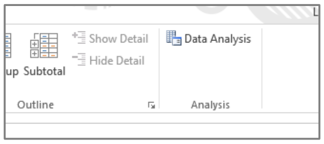
Basic Statistical Analysis in Excel

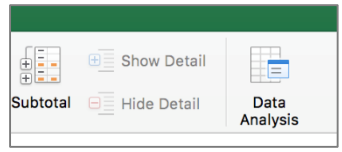
NICAR 2016 Denver / Norm Lewis, University of Florida / nplewis@ufl.edu

ENSURE ANALYSIS TOOLPAK IS ENABLED ON YOUR COMPUTER



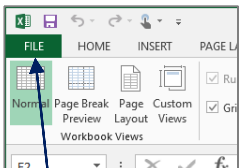
Windows

Microsoft considers Analysis TookPak an “add-in” feature. It comes with Excel (for Windows and for the latest Mac version) but you must enable it first. Check to see if it is loaded by clicking on the Data tab on the ribbon. If yours does not look like one of these examples here, follow steps below.

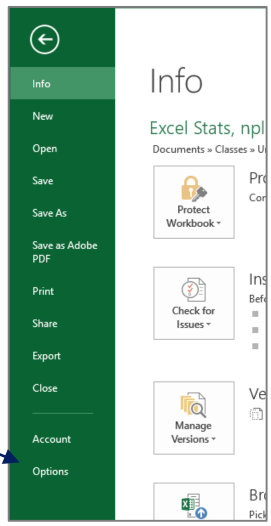


Apple

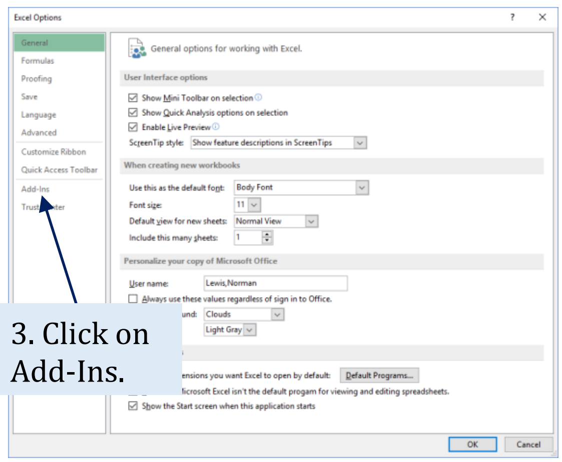
For Windows: Enabling Analysis ToolPak



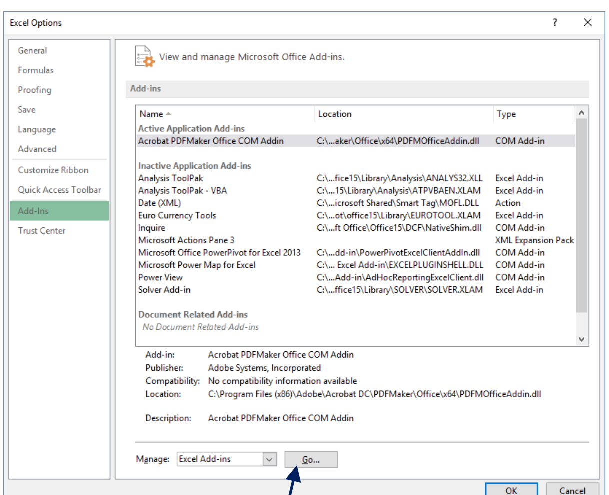
1. Click on the File tab on the ribbon.



2. Click on Options.

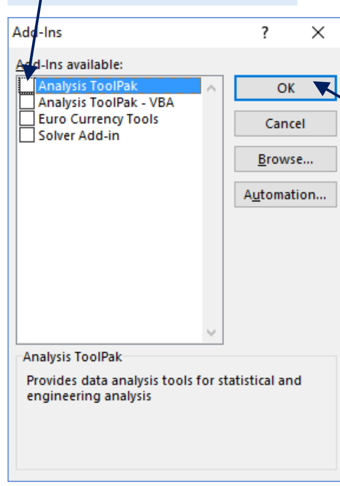


3. Click on Add-Ins.



4. Click Go …

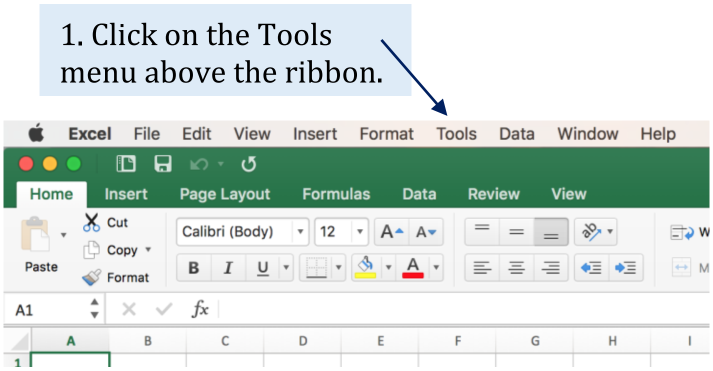
5. Click box for Analysis ToolPak.

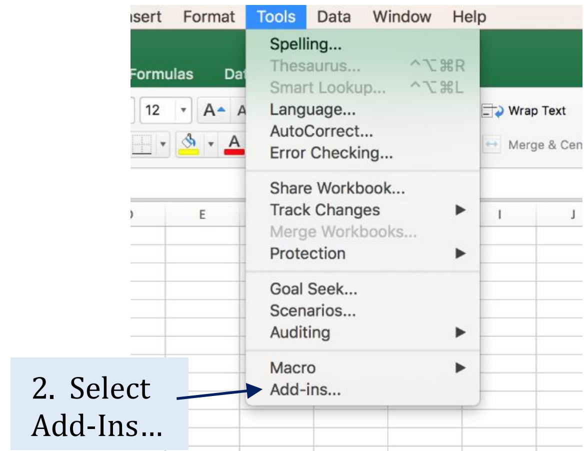


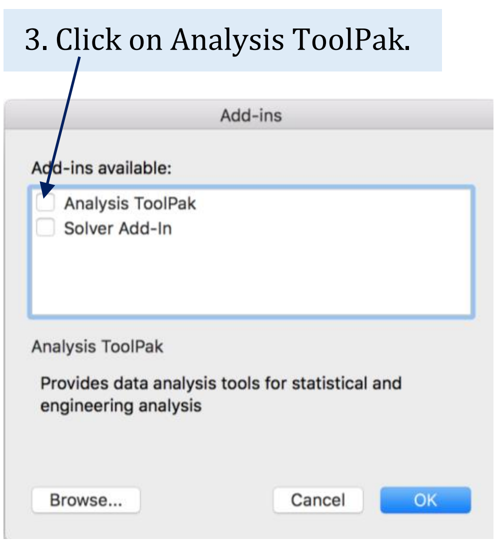
6. Click OK

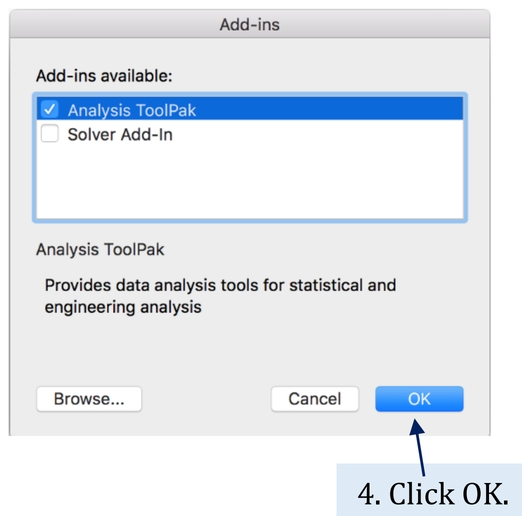
For Macintosh: Installing Analysis ToolPak

If you have the latest version (Office 365 or Office 2016), Microsoft has reinstated the ToolPak. For users of earlier versions, Microsoft removed it and referred Apple users to StatPlus:mac LE from AnalystSoft for free.









Sorry, Mac People

Hey, I'm one of you! But because the computers at the NICAR conference use Windows, the rest of this tutorial will show screenshots from the Windows version. The concepts, however apply equally to us Mac people. (Whew.)

PART 1: AVERAGE

The most common statistic journalists use is average. Average seeks to convey what is typical. Contrary to Excel nomenclature, “average” comes in three flavors:

Type	Excel Function	How Calculated	Usage Example
Mean	=AVERAGE(cells)	Sum divided by number of items	Commute time, water levels
Median	=MEDIAN(cells)	Midpoint of list sorted low to high	Salaries, home prices
Mode	=MODE(cells)	Most frequent occurring number	Donut variety, shoe size

Mean is used so often it is the default. And it works for most of everyday life.

But for numbers that have a potential for outliers such as salaries and houses, the mean overstates what is typical. In those cases, the median is better.

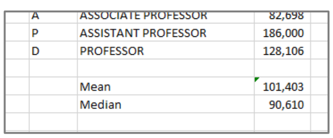
Mode is rarely used in journalism. (It can be used, however, to determine the most popular pizza to order on election night.)

Calculate Mean and Median

Open the Faculty sheet. Go to the bottom. Leave a blank row.

- Write the word Mean. In the next cell, insert the formula =AVERAGE(e2:e1054)
- Write the word Median. In the next cell, insert the formula =MEDIAN(e2:e1054)

You should get the data below.



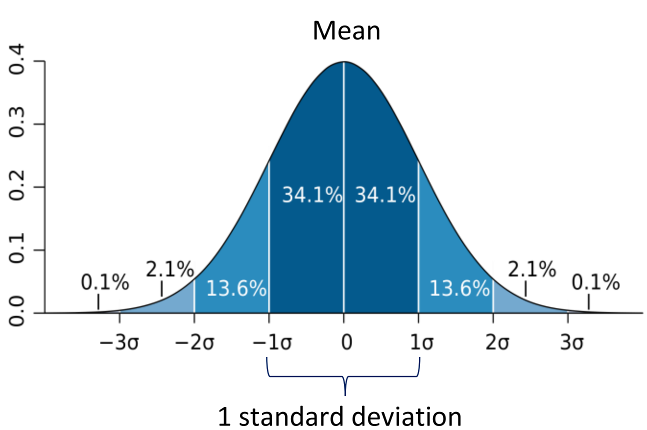
A	ASSOCIATE PROFESSOR	82,698
P	ASSISTANT PROFESSOR	186,000
D	PROFESSOR	128,106
	Mean	101,403
	Median	90,610

Which of these two figures should you use? The mean is higher because it is skewed by some big salaries. Thus, median is a better representation of a typical professor for this data set.

PART 2: STANDARD DEVIATION

But sometimes just knowing the average is not enough. Sometimes it helps to know the dispersion of these numbers. Are most around the mean? Or are they all spread out?

An average alone won’t tell us the dispersion. What can? Analysis ToolPak to the rescue!

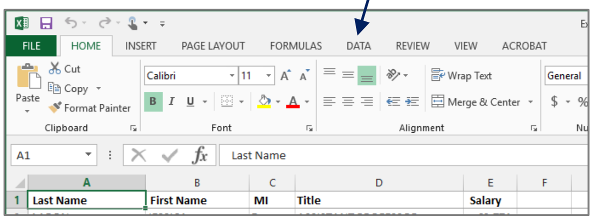


But first, let’s use this picture to describe dispersion. The mean is the center point. The dark blue shade on either side of the mean covers 68 percent of all the numbers. This is 1 standard deviation. Its boundaries are set so that they always include 68 percent of the numbers. How are those boundaries determined? Analysis ToolPak will tell us.

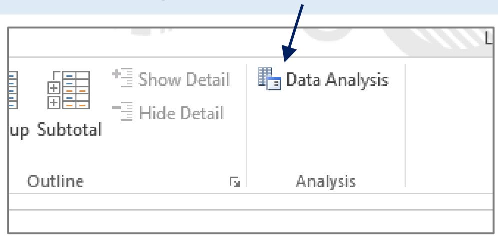
Computing Standard Deviation

We can determine the boundaries of the standard deviation through Analysis ToolPak.

1. Click on Data tab on the ribbon.

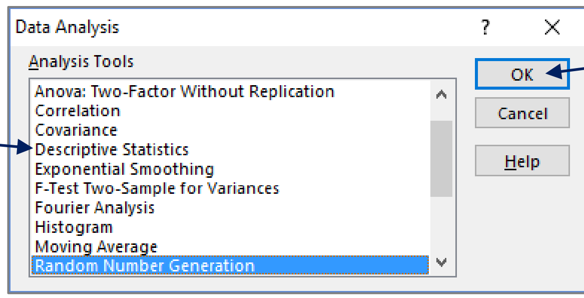


2. On the right, click on Data Analysis.

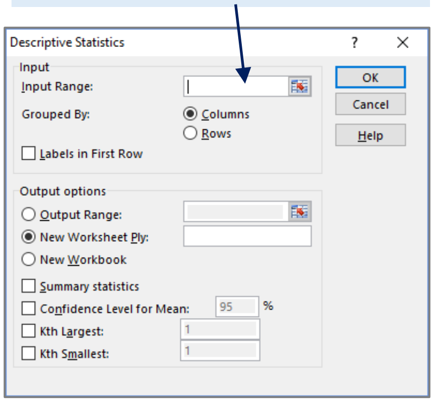


3. Click on Descriptive Statistics.

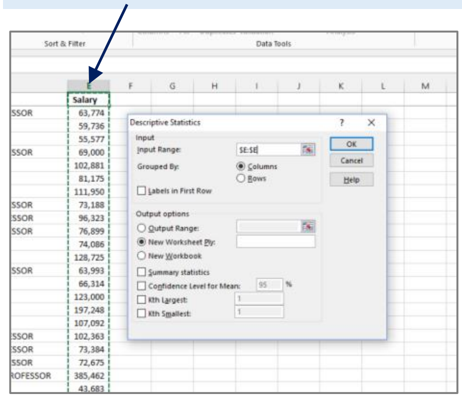
4. Click OK.



5. Click in Input Range box.

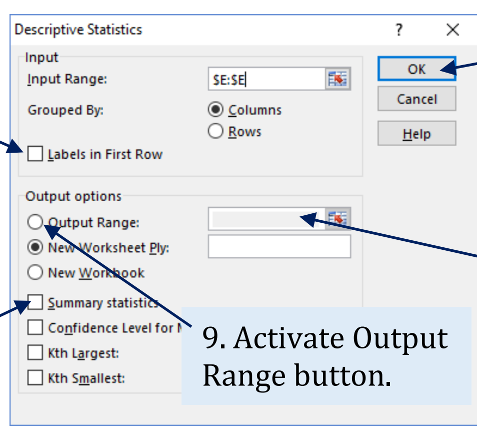


6. Click on the Salary column heading.



7. Click in the box for Labels in First Row.

8. Click in the box beside Summary statistics.



9. Activate Output Range button.

10. In the Output Range box, type G3 or click on the cell where you want the stats inserted.

11. Click OK.

E	F	G	H	I
Salary				
63,774				
59,736		*Salary*		
55,577				
69,000		Mean	101367.5	
102,881		Standard I	1329.429	
81,175		Median	90610	
111,950		Mode	186000	
73,188		Standard I	43139.91	
96,323		Sample Vi	1.86E+09	
76,899		Kurtosis	4.696651	
74,086		Skewness	1.69179	
128,725		Range	382394	
63,993		Minimum	3068	
66,314		Maximum	385462	
123,000		Sum	1.07E+08	
197,248		Count	1053	
107,092				
102,363				

12. Adjust the columns for readability and to line up the decimal points.

Salary	
Mean	101,367
Standard Error	1,329
Median	90,610
Mode	186,000
Standard Deviation	43,140
Sample Variance	1,861,051,794
Kurtosis	5
Skewness	2
Range	382,394
Minimum	3,068
Maximum	385,462
Sum	106,739,939
Count	1,053

Let us now glean some key statistics from this output.

All three averages are provided.

Salary	
Mean	101,367
Standard Error	1,329
Median	90,610
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Standard Deviation	43,140
Sample Variance	1,861,051,794
Kurtosis	5
Skewness	2
Range	382,394
Minimum	3,068
Maximum	385,462
Sum	106,739,939
Count	1,053

The min and max give us the range, which is another way to think about dispersion.

The salaries are summed and counted.

Salary	
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Median	90,610
Mode	186,000
Standard Deviation	43,140
Sample Variance	1,861,051,794
Kurtosis	5
Skewness	2
Range	382,394
Minimum	3,068
Maximum	385,462
Sum	106,739,939
Count	1,053

For this data, 1 standard deviation is $43,140. It is applied to both sides of the mean, like so:

$101,367 + $43,140 = $144,507
$101,367 - $43,140 = $58,227

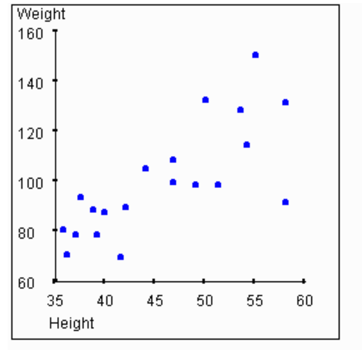
Thus, 68 percent of the salaries are between $58,277 and $144,507.

Interpretation
That is a large range, which means the salaries are widely dispersed. It means that average alone is insufficient to convey a "typical" salary.

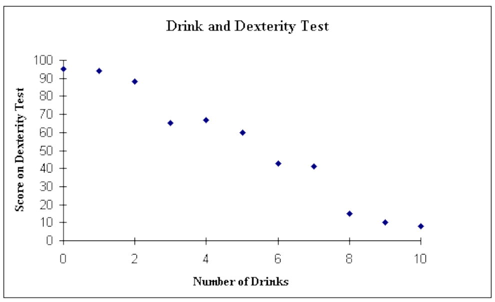
Standard deviation is a relative measure, so the interpretation depends on the underlying data.

PART 3: CORRELATION

Correlation measures whether two things are related: whether they rise and fall together or in opposite directions.



Consider height and weight as in the chart to the right. As people grow taller, they tend to weigh more. Shorter people tend to weigh less. Thus, height and weight are correlated. Further, this is a *positive correlation*: they rise together.



Or think about the relationship between drinking alcohol and dexterity as shown in the chart to the left. As the number of drinks consumed increases, dexterity decreases. As one goes up, the other goes down. This is a *negative correlation*.

Correlations vary between -1 and +1, like this:

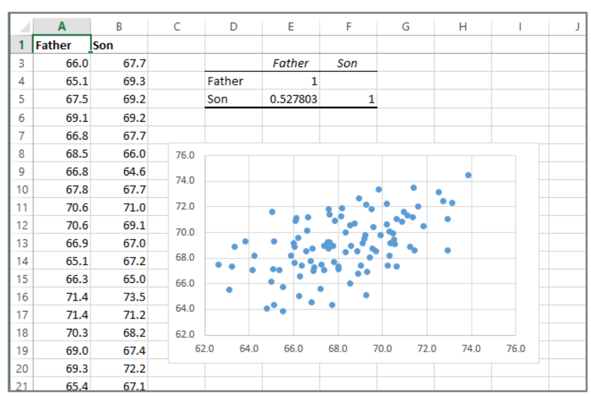
+1	Perfect positive correlation	Two measures rise or fall together
0	No correlation	The two measures have nothing in common
-1	Perfect negative correlation	As one measure increases, the other measure decreases

In the physical world, perfect correlations are not uncommon.

But when it comes to people, few things are correlated beyond -0.7 or +0.7. That's because rarely is any one thing solely correlated with something else. Usually more than one factor is involved. Consider heredity and height.

Heredity and Height

Click on the Height sheet in the Excel data set. You'll see two columns of data from 100 pairs of fathers and sons measuring their height in inches. The scatter chart of blue dots illustrates a messy relationship between the two. As dads get taller, sons do, too. Sort of.



The chart shows the correlation coefficient is 0.527803, or 0.53. There's no negative mark, so the number is positive by default.

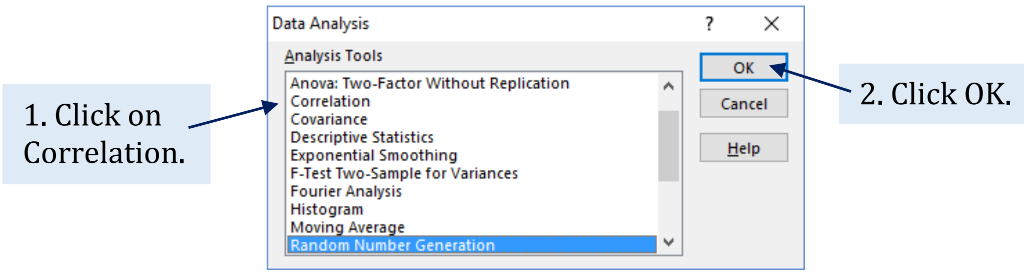
Interpretation

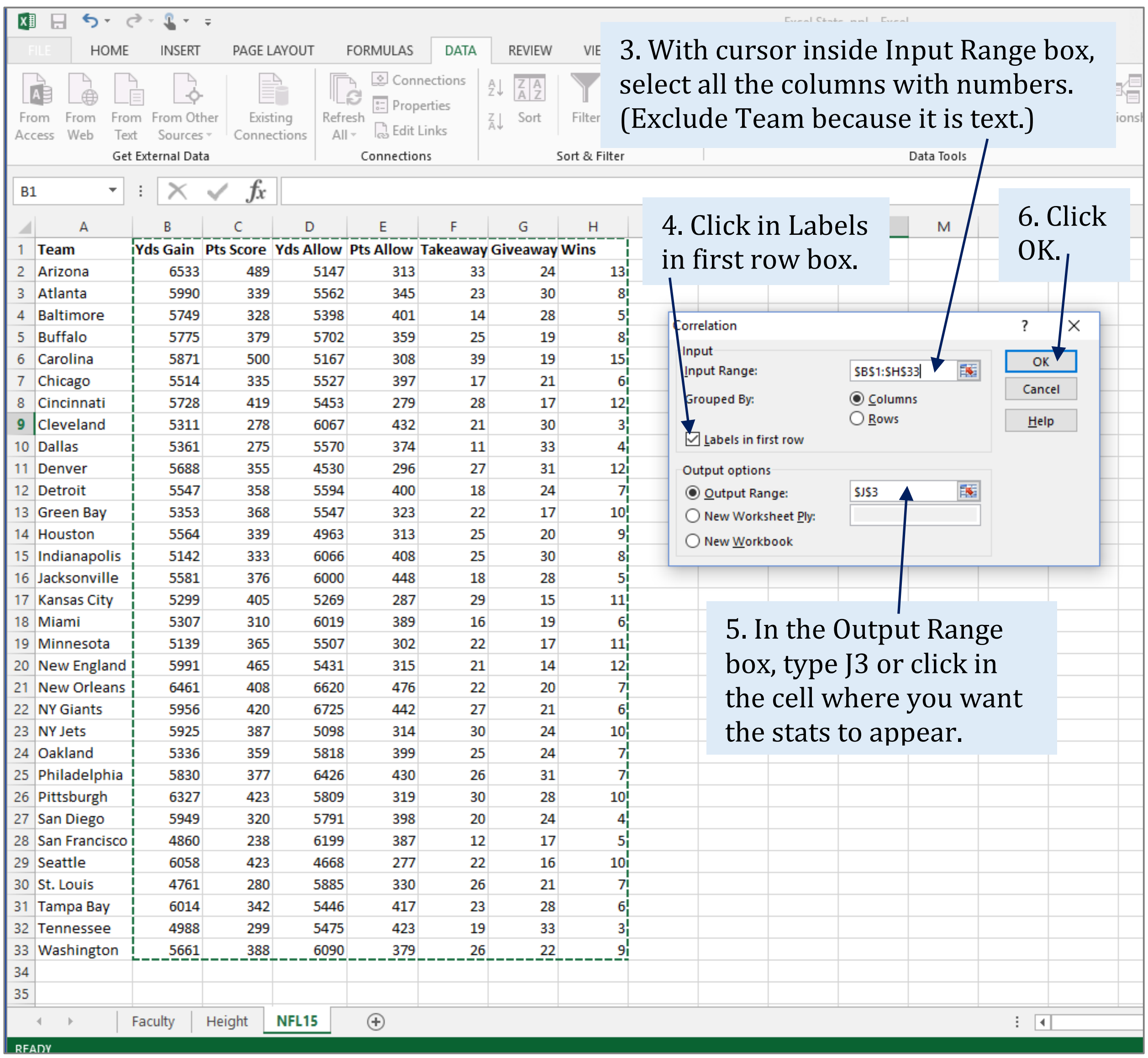
This 0.53 means that for each inch of height a father gains, the son gains about half an inch. That means other factors account for the other 0.47, such as the mother's height and nutrition during childhood.

Calculating Correlation

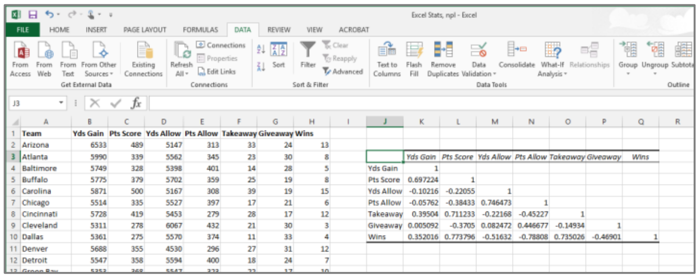
(Hat tip to Professor Steve Doig of Arizona State University, who used a similar data set in a handout a few years ago.)

Open the NFL sheet for the 2015 regular season, according to ESPN statistics. Click on the Data tab, and then on Data Analysis on the right-hand side.





The resulting data look like a triangle. The results are enlarged below.



This area is blank because it would repeat what is below the string of 1's.

These are 1 because they are perfect correlations: yards gained = yards gained.

	Yds Gain	Pts Score	Yds Allow	Pts Allow	Takeaway	Giveaway	Wins
Yds Gain	1						
Pts Score	0.697224	1					
Yds Allow	-0.10216	-0.22055	1				
Pts Allow	-0.05762	-0.38433	0.746473	1			
Takeaway	0.39504	0.711233	-0.22168	-0.45227	1		
Giveaway	0.005092	-0.3705	0.082472	0.446677	-0.14934	1	
Wins	0.352016	0.773796	-0.51632	-0.78808	0.735026	-0.46901	1

For this data, we care most about correlations with wins.

Points scored has a strong correlation with wins: 0.77. It is positive. So the more points scored, the more wins.

The strongest correlation is between wins and points allowed: 0.79. It is negative. So the more points allowed, the fewer wins.

Interpretation

The data here confirm what a sports fan knows: More points scored = more wins. And more points allowed = fewer wins. But the data also reveal other insights:

- Taking the ball away from the other team has a strong correlation with wins.
- Giving the ball away (fumbles, interceptions) is less damaging than takeaways.
- Yards gained don't mean much. On offense, efficiency matters.

Terminology

Correlation does not always mean causation. Points scored do not "cause" wins. Instead, the two are *associated*. Here is an example of how you could write about this data:

> For NFL teams, the defensive statistic that is most closely associated with wins is not yards given up but takeaways – interceptions or recovering fumbles.

But we can do an even better job of evaluating correlations with the next part, regression.

PART 4: LINEAR REGRESSION AND STATISTICAL SIGNIFICANCE

While social scientists use linear regression to predict, journalists use linear regression to determine the amount of change that can be attributed to one factor over others.

Warning! Regression is a more complicated statistic than can be addressed here. It is powerful when used correctly. It is misleading when used incorrectly. If you really want to do linear regression, use something more powerful than Excel, such as SAS, SPSS, PSPP or R. Or, ask a statistician to help.

The purpose here in explaining regression in Excel is to introduce two important concepts: statistical significance and variables.

Statistical Significance

Most of life is a combination of performance and chance. Statistics help differentiate the two – to tell us when something probably wasn't just the luck of the draw.

Note the weasel word *probably*. Certainty is illusive. It's tough to know whether that cancer cluster has an environmental cause or is just bad luck, or whether the team improved because of a new coach or good luck.

That uncertainty is why a common benchmark in evaluating differences is 5 percent. If the chance that luck was the cause is less than 5 percent, something else may be involved. This probability of less than 5 percent in often shown in statistical shorthand as $p < .05$.

How it works can be a bit complicated, so let's apply it to an example: school test scores.

Pretend that Elm School used a new curriculum while Oak School kept the old one. At the end of the school year, test scores for the two are compared. The logic works like this:

1. First, presume that nothing happened. This is the *null hypothesis*.
2. Test scores are compared using a statistical measure such as a *t*-test or ANOVA.
3. If $p < .05$, the null hypothesis is rejected and the alternative hypothesis, that the new curriculum is associated with higher scores, is said to be *supported*.

In other words, statistical significance determines if something is going on beyond chance.

Variables

A *variable* is, well, something that varies. That can be test scores, incidences of cancer, team wins, caffeine ingested on deadline – or just about anything that can change.

Variables come in several flavors. All that matters at this point is to know that regression requires *continuous* variables such as temperature, weight and money. It does not work with *categorical* variables such as religion, ethnicity or birthplace.

Click on the NFL data sheet. Consider the column headers as variables. Yards gained, points, takeaways, etc., all can vary.

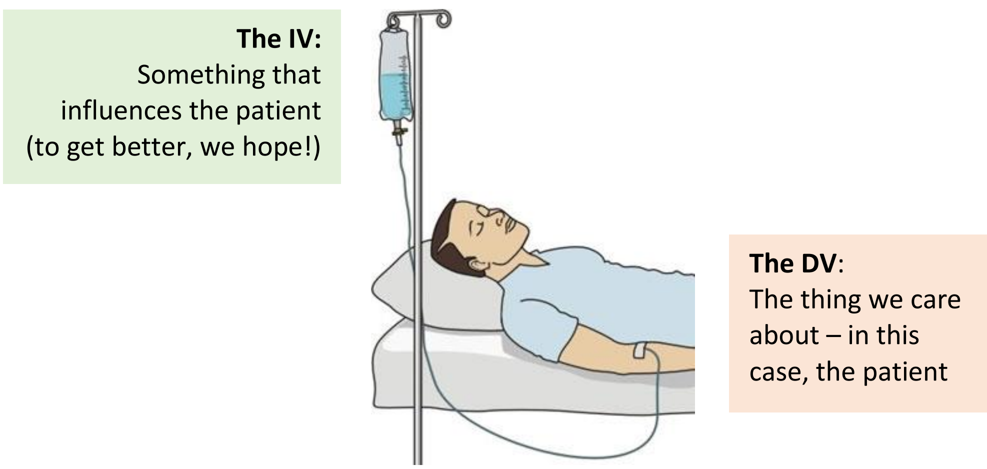
	A	B	C	D	E	F	G	H
1	**Team**	**Yds Gain**	**Points**	**Takeaway**	**Giveaway**	**Yds Allow**	**Pts Scored**	**Wins**
2	Arizona	5,116	310	25	17	5,891	299	11
3	Atlanta	6,051	381	28	23	6,372	417	6

Dependent and Independent Variables

The *dependent variable* is the variable we care most about. That could be school test scores, cancer rates or income. In this data set, Wins is the dependent variable, or DV for short.

The *independent variable* is something that could influence or be associated with the DV. In this data set, everything besides Wins is an independent variable, or IV for short.

Here's a visual way to remember the difference between an independent variable (IV) and the dependent variable (DV), drawing from the medical shorthand for intravenous: IV.



Further, this picture gives us the order. The IV comes first. It goes into the patient to deliver medicine and fluids. And if the IV works, the result is the patient gets better.

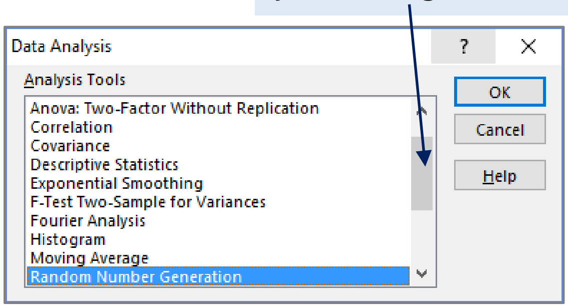
Just as the medical IV comes first, so does X come first in the alphabet before Y. Thus, we will put the IVs in the X box for Excel. And the DV will go in the Y box.

Variable	Abb	Excel	Role	Alternate name
Independent Variable	IV	X	Thing(s) that change the DV	Predictor Variable
Dependent Variable	DV	Y	The thing that changes	Criterion Variable

Linear Regression in Excel

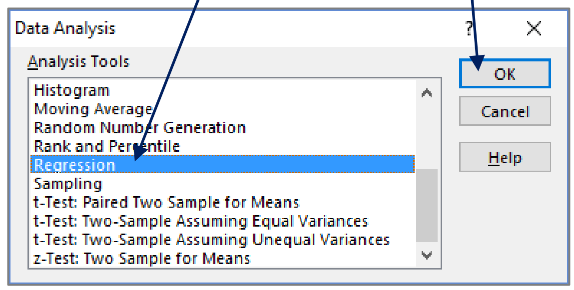
On the NFL sheet, click on the Data tab. On the far right, choose the Data Analysis option. When you do, you trigger this box. Scroll down until you get to regression.

1. Scroll down until you see Regression.



2. Select Regression.

3. Click OK.

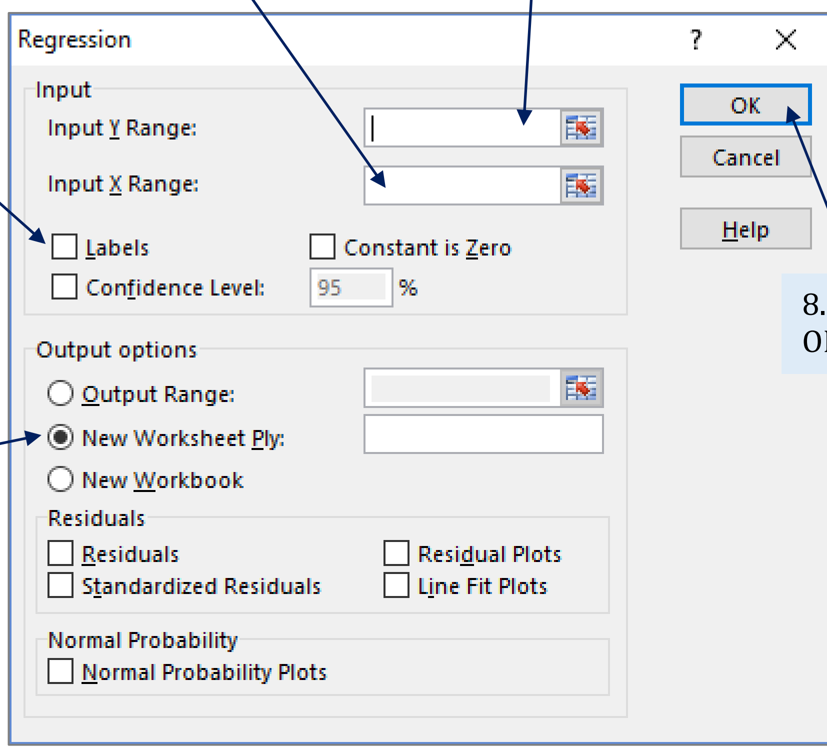


5. In the Input X Range box, use the mouse to select all the other data columns (exclude Team) as IVs.

4. In the Input Y Range box, use the mouse to select Wins, the DV.

6. Click in the box for Labels.

7. The statistics can take up space, so retain the default of a new worksheet.



8. Click OK.

Column widths were stretched to make the contents more readable.

Regression statistics speak to how well the regression model does in predicting the DV.

ANOVA is Analysis of Variance. The relatively large F statistic says there is a pattern in this data beyond luck, or noise.

This is scientific notation. The E-11 means: move 11 decimal points to the left. Suffice to say that $p < .05$ has been met.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.950358485
R Square	0.903181249
Adjusted R Square	0.879944749
Standard Error	1.056102271
Observations	32

ANOVA

	df	SS	MS	F	Significance F
Regression	6	260.1161998	43.35269997	38.86907428	1.71241E-11
Residual	25	27.88380015	1.115352006		
Total	31	288			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	10.7368363	3.696558726	2.904549095	0.007585339	3.123631094	18.35004151	3.123631094	18.35004151
Yds Gain	-0.00079139	0.000700988	-1.12896489	0.269629882	-0.002235101	0.000652321	-0.002235101	0.000652321
Pts Score	0.026529358	0.007037992	3.769449658	0.000893453	0.012034341	0.041024375	0.012034341	0.041024375
Yds Allow	8.64358E-05	0.000664259	0.130123599	0.897510003	-0.001281631	0.001454503	-0.001281631	0.001454503
Pts Allow	-0.02803259	0.007212296	-3.88677737	0.000662274	-0.042886592	-0.013178588	-0.042886592	-0.013178588
Takeaway	0.086261653	0.053525871	1.611588039	0.119606381	-0.023976941	0.196500248	-0.023976941	0.196500248
Giveaway	-0.00903921	0.048830169	-0.18511536	0.854632172	-0.10960683	0.091528402	-0.10960683	0.091528402

We care most about these P-values, so let's focus on this column and evaluate.

Ignore Intercept, which has to do with building a regression equation.

	P-value
Intercept	0.007585339
Yds Gain	0.269629882
Pts Score	0.000893453
Yds Allow	0.897510003
Pts Allow	0.000662274
Takeaway	0.119606381
Giveaway	0.854632172

When these factors were entered into a regression equation, only two variables achieved statistical significance at $p < .05$.

Interpretation

Only points scored and points allowed were statistically significant. No other variable had a *p*-value of less than 0.05.

One journalistic approach would be to remove the two points columns (they are, after all, rather obvious) and re-test for the remaining variables. Then we could write a story that reveals whether factors beyond points are associated with wins.

Further, this regression equation is just for the variables selected. We might want to add in other variables such as the average team quarterback rating and the portion of the season starters missed due to injuries.