

University of North Texas
Department of Geography and the Environment

GEOG 5190

**LAB 1: ELEMENTARY MATRIX ALGEBRA
AND INTRODUCTION TO SPSS**

Part A: Elementary Matrix Algebra

1. One matrix operation we discussed in class was matrix multiplication.

- a. Please complete the multiplication of matrix A and matrix B below (show all steps of your work to demonstrate how you arrive at your answer).

$$A \cdot B = \begin{bmatrix} 3 & 4 \\ -1 & 2 \\ 2 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 3 \\ -1 & -1 \end{bmatrix} = ?$$

- b. How can you tell that it is possible to multiply matrix A and matrix B as shown?
- c. Could you multiply these matrices if they were reversed? In other words, would the calculation work if the multiplication was $B \cdot A$ instead of $A \cdot B$ (with A and B as shown above)?

2. Determinant and inverse calculations are also an important part of dealing with matrices.

- a. Please find the determinant of the following matrix as explained in class (again, show all of your work):

$$\begin{bmatrix} 8 & 6 \\ 6 & 7 \end{bmatrix}$$

- b. Based on the determinant value you calculated, does an inverse exist for this matrix? If so, please also determine the inverse.

3. Please solve the following system of simultaneous linear equations by hand using the matrix method discussed in class (show all of your work).

$$\begin{array}{rclcl} X & + & 3Y & = & 14 \\ 3X & - & Y & = & 12 \end{array}$$

4. What does the solution to question 3 (of the form $X = \underline{\quad}$, $Y = \underline{\quad}$) actually mean? In other words, think back to (what should have been covered in) your high school algebra class to explain the interpretation of this pair of values. Please explain fully, but briefly (one really well-worded sentence could be enough).

- **Hint:** drawing and using a rough sketch graph of X versus Y, showing the lines defined by the two equations, can help you make your explanation more concise and to the point – no pun intended.

Part B: The SPSS Software Package

This next part of the lab is meant to ensure you are familiar with the basic operation of the SPSS software package (“Statistical Package for the Social Sciences”). If you are already familiar with SPSS, then the following shouldn’t take long. We will use SPSS for a good portion (but not all) of our lab work in this course. Doing this exercise also gives us a chance to run through the “six steps” of a formal statistical test (as discussed in our first classroom session).

In the lab stages beginning below, please provide answers for any question (boxed and printed in bold). Please label your responses using the question number given – e.g. Question 1, Question 2, etc. Note that some of the steps below do not have a question requiring a written answer, although you will still need to complete all actions requested in each step.

Stage 1. Take a few minutes to explore the SPSS program. Look especially at the “Analyze” and “Graphs” menus.

Question 1: Which statistical tests do you recognize? Which ones are unfamiliar to you? What kinds of capabilities are available for graphical output of data?

Aside: A look through the SPSS “Help” menu can help you find out how to run some of the statistical tests you are already familiar with.

Stage 2. Now, let’s take a run through one of the statistical tests you should have learned before taking this course: the t-test of the difference between two sample means. If you need to, please review the meaning and goals of a t-test analysis on your own. The data set we will test (a comparison of how well two statistical models performed over a five year period) looks like this:

<i>Year</i>	<i>Model 1 Error (%)</i>	<i>Model 2 Error (%)</i>
2013	12	4
2014	9	5
2015	11	9
2016	8	11
2017	10	6
Mean	10	7

To interpret these statistics, note that these are error values and not the actual calculated values produced by the model, and that the bigger the error, the worse the model.

Stage 3. PLEASE READ THE FOLLOWING CAREFULLY (read it more than once if you need to, and don't be afraid to ask questions in the lab session):

The important data in the table from stage 2 are contained in columns 2 and 3 of that table; it is this information that we now need to transfer into SPSS.

- Make sure you are in “Data View” mode (you should be in this mode by default: to check, see the “Data View” and “Variable View” tabs at the bottom of the SPSS screen, and make sure the “Data View” tab is the current one).
- In the first column of the data window, type all of the data for model 1 and model 2 errors. In other words, the first column in your SPSS window will have the data for both model 1 and model 2. The second column will indicate, by row, whether the error refers to model 1 or model 2.
- Switch to “Variable View” mode and name the first column “Error” and the second “Model”.

When you've done all this, the SPSS screen should look something like the graphic below.

Data entry screen snapshot:

	Error	Model	var
1	12.00	1.00	
2	9.00	1.00	
3	11.00	1.00	
4	8.00	1.00	
5	10.00	1.00	
6	4.00	2.00	
7	5.00	2.00	
8	9.00	2.00	
9	11.00	2.00	
10	6.00	2.00	
11			

With the data entry complete as shown above, you are ready to begin the statistical analysis of this simple dataset.

Stage 4. The exercise from here on is simply following the six steps of a formal statistical test to complete your t-test analysis. You are given that:

1. You are simply looking to test if there is a statistically-significant difference between the two models, not whether one model is better than the other.
2. For your purposes, a significance level of 0.05 is sufficient.

Using all that you have done and been given to this point, the following walks you through each of the “six steps”, along with some items for you to consider for each step. Please document your work in your lab submission by step number (you will also find some numbered questions you will need to answer as well).

- **Step 1: Formulate hypotheses (H_0 and H_1)**

- State each of these hypotheses clearly, in a manner appropriate to a t-test analysis. Both H_0 and H_1 are necessary.
- Choose an appropriate H_1 (either one- or two-tailed), based on the information provided in this lab.
- Be sure to explain why the form of alternative hypothesis you have chosen is the best choice for this situation:
 - If you choose a one-tailed test: you will need to explain why a one-tailed test is most appropriate. Also, if you choose this option you will need to specify a direction and again justify why this direction is most appropriate.
 - If you choose a two-tailed test: you will need to explain why this is the most appropriate choice. This is a simple case, so no further discussion is needed beyond the basic justification if you choose the two-tailed option.

- **Step 2: Select a test statistic**

- You know you are using a t-test, so you can simply state this here (please do that for a complete record). Please also explain (briefly) why this statistic is an appropriate choice for your situation.

- **Step 3: Select your significance level and whether to use a one- or two-tailed test**

- Please use the 0.05 level (again, please state that here for completeness).

- **Step 4: Look up the critical value for acceptance/rejection of H_0**

- Use the critical value table provided on the following page, and note the correct critical value for your situation.

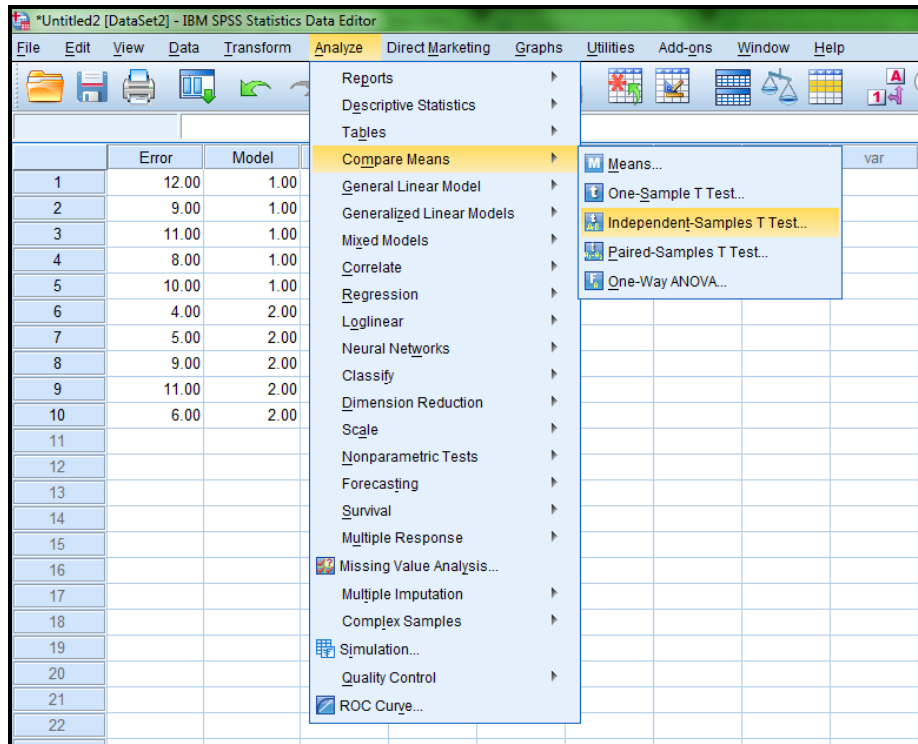
Table: Critical Values of Student's t

Degrees of Freedom	Significance Level (One-Tailed)						
	0.05	0.025	0.01	0.005	0.0025	0.001	0.0005
	Significance Level (Two-Tailed)						
	0.1	0.05	0.02	0.01	0.005	0.002	0.001
1	6.3138	12.7065	31.8193	63.6551	127.3447	318.493	636.045
2	2.9200	4.3026	6.9646	9.9247	14.0887	22.3276	31.5989
3	2.3534	3.1824	4.5407	5.8408	7.4534	10.2145	12.9242
4	2.1319	2.7764	3.7470	4.6041	5.5976	7.1732	8.6103
5	2.0150	2.5706	3.3650	4.0322	4.7734	5.8934	6.8688
6	1.9432	2.4469	3.1426	3.7074	4.3168	5.2076	5.9589
7	1.8946	2.3646	2.9980	3.4995	4.0294	4.7852	5.4079
8	1.8595	2.3060	2.8965	3.3554	3.8325	4.5008	5.0414
9	1.8331	2.2621	2.8214	3.2498	3.6896	4.2969	4.7809
10	1.8124	2.2282	2.7638	3.1693	3.5814	4.1437	4.5869
11	1.7959	2.2010	2.7181	3.1058	3.4966	4.0247	4.4369
12	1.7823	2.1788	2.6810	3.0545	3.4284	3.9296	4.3178
13	1.7709	2.1604	2.6503	3.0123	3.3725	3.8520	4.2208
14	1.7613	2.1448	2.6245	2.9768	3.3257	3.7874	4.1404
15	1.7530	2.1314	2.6025	2.9467	3.2860	3.7328	4.0728
16	1.7459	2.1199	2.5835	2.9208	3.2520	3.6861	4.0150
17	1.7396	2.1098	2.5669	2.8983	3.2224	3.6458	3.9651
18	1.7341	2.1009	2.5524	2.8784	3.1966	3.6105	3.9216
19	1.7291	2.0930	2.5395	2.8609	3.1737	3.5794	3.8834
20	1.7247	2.0860	2.5280	2.8454	3.1534	3.5518	3.8495
21	1.7207	2.0796	2.5176	2.8314	3.1352	3.5272	3.8193
22	1.7172	2.0739	2.5083	2.8188	3.1188	3.5050	3.7921
23	1.7139	2.0686	2.4998	2.8073	3.1040	3.4850	3.7676
24	1.7109	2.0639	2.4922	2.7970	3.0905	3.4668	3.7454
25	1.7081	2.0596	2.4851	2.7874	3.0782	3.4502	3.7251
26	1.7056	2.0555	2.4786	2.7787	3.0669	3.4350	3.7067
27	1.7033	2.0518	2.4727	2.7707	3.0565	3.4211	3.6896
28	1.7011	2.0484	2.4671	2.7633	3.0469	3.4082	3.6739
29	1.6991	2.0452	2.4620	2.7564	3.0380	3.3962	3.6594
30	1.6973	2.0423	2.4572	2.7500	3.0298	3.3852	3.6459
40	1.6839	2.0211	2.4233	2.7045	2.9712	3.3069	3.5510
60	1.6706	2.0003	2.3901	2.6603	2.9146	3.2317	3.4602
120	1.6577	1.9799	2.3578	2.6174	2.8599	3.1595	3.3735

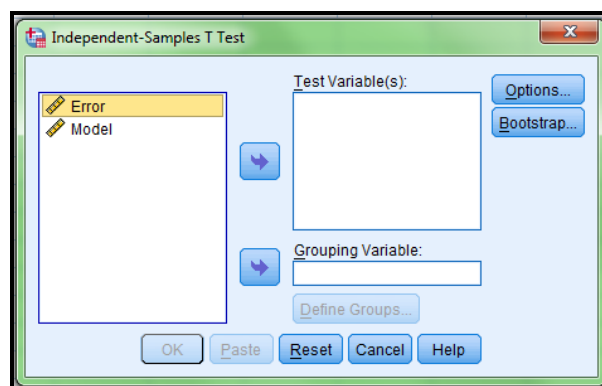
Reject H_0 if the calculated value is **greater than** the critical value at the chosen significance level.

- **Step 5: Compute the test statistic from your data**

- Go up to the “Analyze” menu and “Compare Means” submenu (Analyze > Compare Means). This presents a number of options (see graphic below). Select “Independent Samples T Test” as your test.

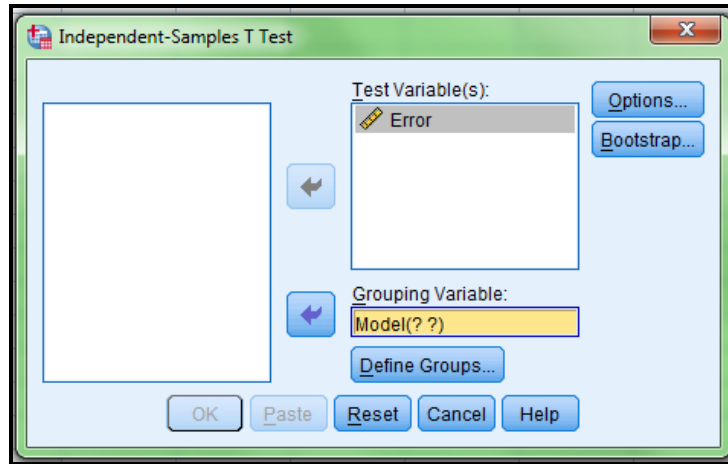


- Selecting “Independent Samples” brings up a new window (see below). Down the left side of the window is a list of available variables (Error, Model), while in the middle two other windows indicate spaces to be filled by you: “Test Variable(s)” and “Grouping Variable”.

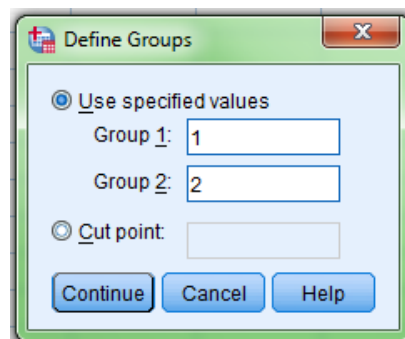


- Click on “Error” and the upper arrow button to move it over to “Test Variable(s)”. The error variable contains the actual data we will test.

- Click on model and the lower arrow button to move it over to “Grouping Variable”. The graphic below shows what the window should look like once you have set both the test variable and the grouping variable as outlined above:



- With stage 6 done, click on “Define Groups...” to bring up a new dialogue box. In this “Define Groups...” box (see below), select the “Use specified values” radio button.
 - In the box beside “Group 1”, type the number 1.
 - Beside “Group 2”, type the number 2.
 - When you’ve done this, click on “Continue” to take you back to the “Independent Samples T Test” Window.



- Once back in the “Independent Samples T Test” window, click on the “Options” button.

Question 2: What options do you see? Use the “Help” button to find out what the options mean. Close the “Help” window to get back to the “Options” window, and click on “Cancel” to return to the “Independent Samples T Test” window.

- At this stage, if you’ve followed each lab stage correctly, everything that needs to be done to run the t-test is completed. Click on “OK”.
 - The output window will become visible, and fills with the results of the t-test.
 - Note the two major tables that come up: the first, with “Variable” in the first column, and the second, with “Variances” in the first column.
- The first table tells us about each model: the number of cases, the mean error of each, the standard deviation, and the standard error of the mean.

Question 3: Put into your own words what we can tell about the two models from this information.

- The second table gives us the results of the t-test itself. There are some variables listed in this table that we will not need right now. In the second table, please refer to the row labelled “Equal variances not assumed” for the numbers you need:
 - The calculated t-value (“t”) and the degrees of freedom (“df”: round this value down to an integer to use your tables).
 - The 2-tailed significance level at which we can reject the null hypothesis (“Sig. (2-tailed)”)

We’ll ignore all the other values for now.

Question 4: What is the calculated t-value, the degrees of freedom, and the 2-tailed significance level?

- **Step 6: Make a decision: accept or reject H_0 ?**

- Refer to all of the information you have already gathered. **Make your decision, and explain it well.**

**Please remember to include a copy of your SPSS output
in your written report.**

**Feel free to also integrate selected tables from the SPSS output in
your answers above wherever you think that could be helpful.**