PS4

2024-09-18

Stat 5000 Homework #4
Fall 2024 due Fri, Sep 27th @ 11:59 pm Name:
Collaborators:

Directions: Type or clearly handwrite your solutions to each of the following exercises. Partial credit cannot be given unless all work is shown. You may work in groups provided that each person takes responsibility for understanding and writing out the solutions. Additionally, you must give proper credit to your collaborators by providing their names on the line below (if you worked alone, write "No Collaborators"):

1.

Consider the dataset from Homework #1 about survival times (in days) of guinea pigs that were randomly assigned either to a control group or to a treatment group that received a dose of tubercle bacilli (a bacterium that causes tuberculosis). These data are found in the `guinea_pigs.csv` file located in our course's shared folder on SAS Studio. Suppose the researchers want to test the hypothesis that the mean (or median/distribution of) survival times are the same for controls and the guinea pigs infected with tubercle bacilli against the **one-sided** alternative that infection with tubercle Bacilli tends to decrease survival times.

1. Perform a two-sample t-test assuming two independent random samples from normal distributions with equal variances in SAS Studio. Report (i) the observed t-statistic and (ii) the p-value.

2. Perform a two-sample Welch t-test assuming two independent random samples from normal distributions with unequal variances (using the Satterthwaite approximation) in SAS Studio. Report (i) the observed t^*-statistic and (ii) the p-value.

T-test for Difference in Mean Times - Survival Time

The TTEST Procedure

Variable: Time

Treatment	Method	N	Mean	Std Dev	Std Err	Minimum	Maximum
Bacilli		58	242.5	117.9	15.4851	76.0000	598.0
Control		64	345.2	222.2	27.7767	18.0000	735.0
Diff (1-2)	Pooled		-102.7	180.4	32.6978		
Diff (1-2)	Satterthwaite		-102.7		31.8015		

Treatment	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
Bacilli		242.5	211.5	273.5	117.9	99.6997	144.4
Control		345.2	289.7	400.7	222.2	189.3	269.1
Diff (1-2)	Pooled	-102.7	-167.4	-37.9448	180.4	160.1	206.5
Diff (1-2)	Satterthwaite	-102.7	-165.8	-39.5736			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	120	-3.14	0.0021
Satterthwaite	Unequal	97.803	-3.23	0.0017

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	63	57	3.55	<.0001

Figure 1: Figure 1

Variable: Time

Treatment	Method	N	Mean	Std Dev	Std Err	Minimum	Maximum
Bacilli		58	242.5	117.9	15.4851	76.0000	598.0
Control		64	345.2	222.2	27.7767	18.0000	735.0
Diff (1-2)	Pooled		-102.7	180.4	32.6978		
Diff (1-2)	Satterthwaite		-102.7		31.8015		

Figure 2: Figure 1

3. Perform a randomization/permutation test using 20,000 new random assignments of guinea pigs to treatment groups in SAS Studio. Report (i) the observed difference in sample means and (ii) the p-value.

GLM results for Difference in Mean Survival Times

The Multtest Procedure

Model Information	
Test for continuous variables	Mean t-test
Degrees of Freedom Method	Pooled
Tails for continuous tests	Two-tailed
Strata weights	None
P-value adjustment	Permutation
Center continuous variables	No
Number of resamples	20000
Seed	500

Contrast Coefficients			
		Treatment	
Contrast		Bacilli	Control
Trend	Centered	-0.5	0.5

Continuous Variable Tabulations				
Variable	Treatment	NumObs	Mean	Standard Deviation
Time	Bacilli	58	242.5345	117.9309
Time	Control	64	345.2188	222.2139

p-Values			
Variable	Contrast	Raw	Permutation
Time	Trend	0.0021	0.0023

Figure 3: Figure 1

4. Perform the Wilcoxon rank-sum test in SAS Studio. Report (i) the sum of the ranks w, for the Bacilli treatment group and (ii) the p-value.

GLM results for Difference in Mean Survival Times

The NPAR1WAY Procedure

Wilcoxon Scores (Rank Sums) for Variable Time Classified by Variable Treatment

Treatment	N	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Bacilli	58	3190.50	3567.0	195.053487	55.008621
Control	64	4312.50	3936.0	195.053487	67.382813

Average scores were used for ties.

Wilcoxon Two-Sample Test

Statistic	Z	Pr < Z	Pr > |Z|	t Approximation Pr < Z	t Approximation Pr > |Z|
3190.500	-1.9277	0.0269	0.0539	0.0281	0.0562

Z includes a continuity correction of 0.5.

Kruskal-Wallis Test

Chi-Square	DF	Pr > ChiSq
3.7258	1	0.0536

Figure 4: Figure 1

5. Compare the results from parts (a)–(d).

2.

Revisit the guinea pig study from the previous exercise. Use SAS to create diagnostic information to assess the assumptions for the traditional t-based inference procedure.

1. There is not enough information provided to assess independence of observations within each group. Which study design aspects would help you assess the assumption of independence between the groups.

2. Assess the assumption of equal variances using:

    1. the ratio of standard deviations;

    2. side-by-side boxplots;

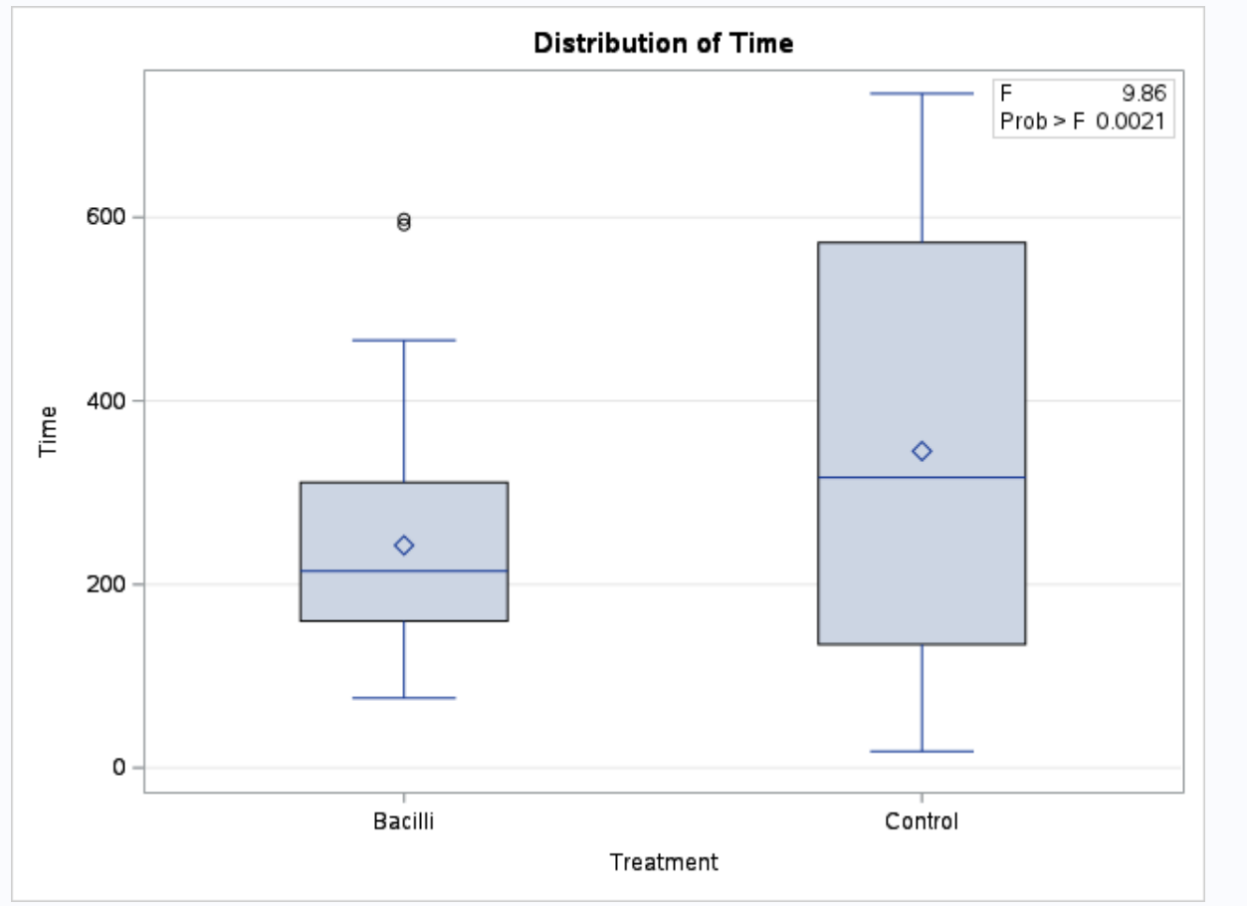


Figure 5: Figure 1

3. the F-test;

4. the Brown-Forsythe test.

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	63	57	3.55	<.0001

Figure 6: Figure 1

GLM results for Difference in Mean Survival Times

The GLM Procedure

Brown and Forsythe's Test for Homogeneity of Time Variance ANOVA of Absolute Deviations from Group Medians					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatment	1	359581	359581	42.80	<.0001
Error	120	1008165	8401.4		

Figure 7: Figure 1

3. Assess the assumption of normality using the following methods:

    1. side-by-side histograms;

    2. Q-Q plot(s);

    3. the Shapiro-Wilk test.

4. Based on what you learned in parts (a)–(c), complete the following exercises.

    1. Summarize the assessment of all three assumptions.

    2. Discuss which tests are the most appropriate among the 4 used in the previous exercise.

    3. Interpret the result, in the context of the study, for one of the tests you chose.

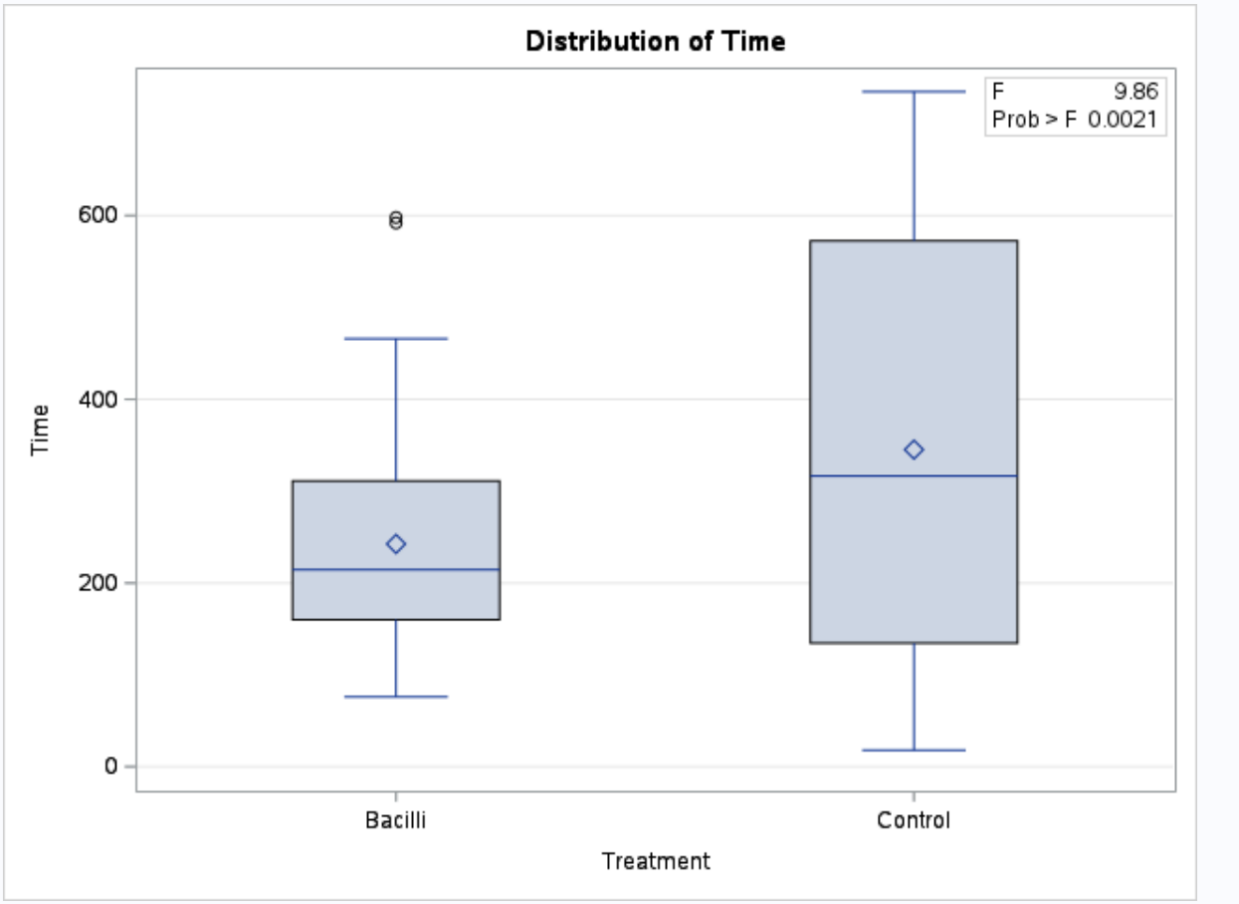


Figure 8: Figure 1

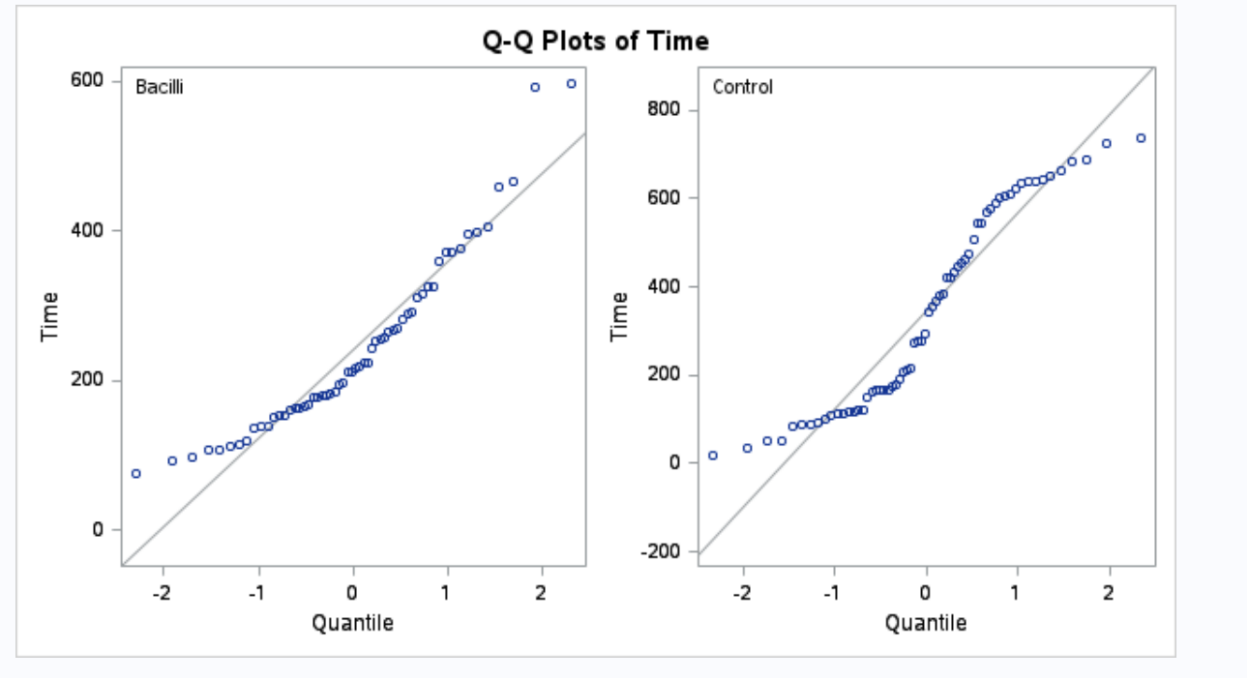


Figure 9: Figure 1

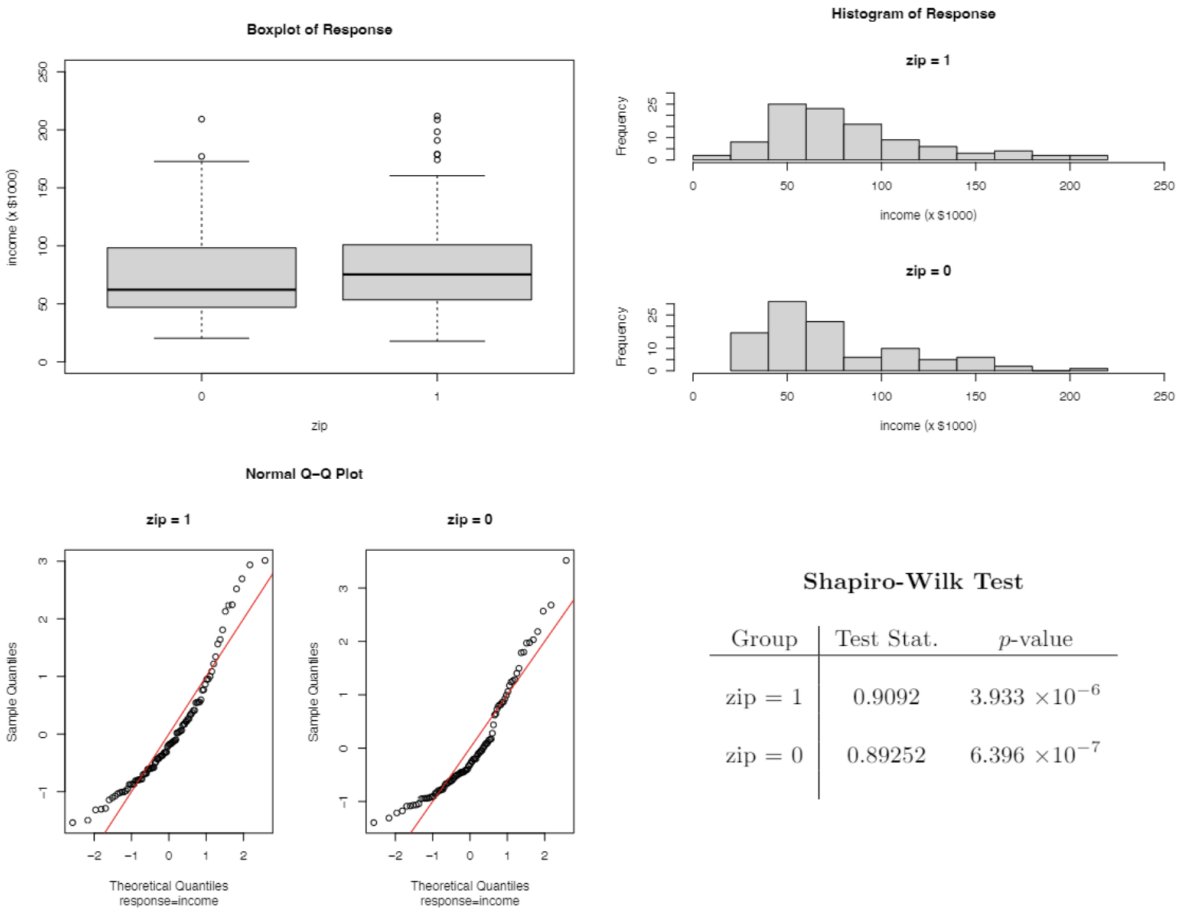
Tests for Normality				
Test	**Statistic**		**p Value**	
Shapiro-Wilk	**W**	0.91559	**Pr < W**	0.0006
Kolmogorov-Smirnov	**D**	0.128064	**Pr > D**	0.0188
Cramer-von Mises	**W-Sq**	0.212674	**Pr > W-Sq**	<0.0050
Anderson-Darling	**A-Sq**	1.317813	**Pr > A-Sq**	<0.0050

Figure 10: Figure 1

3.

Researchers have data consisting of the annual adjusted gross incomes (`income`) for 100 randomly sampled individuals from two adjacent zip codes (`zip`). What type of statistical analysis should you use to compare the incomes in the two zip codes?

1. The output below was created to diagnose the assumption of normality for this data.



Shapiro-Wilk Test

Group	Test Stat.	p-value
zip = 1	0.9092	3.933×10^{-6}
zip = 0	0.89252	6.396×10^{-7}

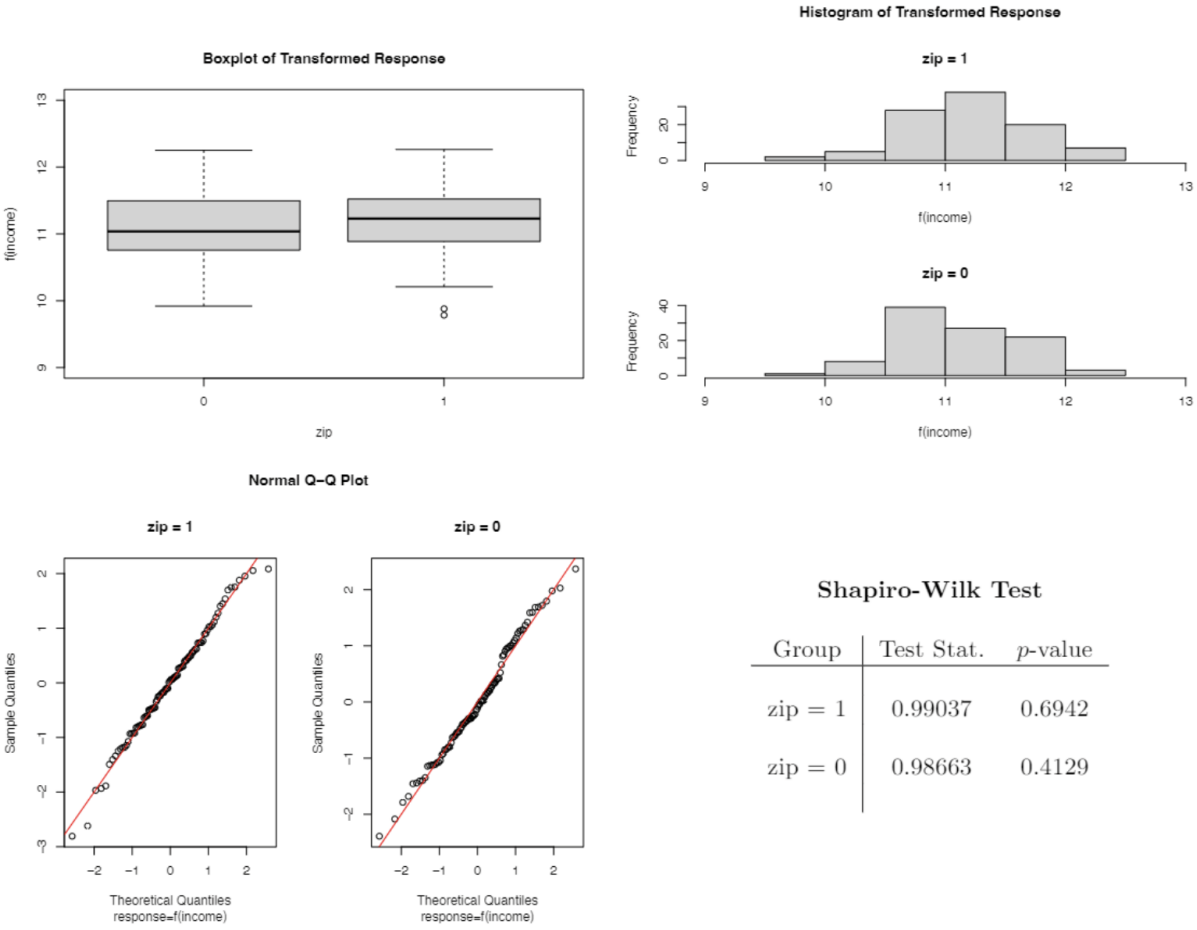
Figure 11: Figure 1

   Describe three aspects (minimum) that indicate the normality assumption is violated.

2. Using the information you gathered in part (a), which transformation should be explored to achieve normality? Choose one: logarithm, square-root, arcsine, or power/Box-Cox.

3. One of these transformations has been applied and the resulting diagnostic output is provided below.

Did the transformation succeed in remediating the non-normality?



Shapiro-Wilk Test

Group	Test Stat.	p-value
zip = 1	0.99037	0.6942
zip = 0	0.98663	0.4129

Figure 12: Figure 2

4.

Given the additional output (shown below) to diagnose the equal variance assumption, how should you proceed with the data analysis?

- Summary statistics: $s_0 = 0.4899$, $s_1 = 0.5067$, ratio $= 1.0342$
- F-test: statistic $= 1.0696$, p-value $= 0.3692$
- Brown-Forsythe test: statistic $= 0.0125$, p-value $= 0.9109$

Total: 50 points **# correct: %:**