EPS 625 – INTERMEDIATE STATISTICS
FRIEDMAN TEST

The Friedman test is an extension of the Wilcoxon test. The Wilcoxon test can be applied to repeated-measures data if participants are assessed on two occasions or conditions or matched-subjects data if participants are matched in pairs. In contrast, the Friedman test allows for the analysis of repeated-measures data if participants are assessed on two or more occasions or conditions or to matched-subjects data if participants are matched in pairs, triplets, or in some greater number.

The Friedman test is applicable to problems with repeated-measures designs or matched-subjects designs. With repeated-measures designs, each participant is a case in the SPSS data file and has scores on *K* variables, the score obtained on each of the *K* occasions or conditions. A researcher is interested in determining if subjects changed significantly across occasions (or conditions). For a matched-subjects design, participants are matched in sets of *K* participants, and each participant in a set is assessed once on a measure. Each set of participants is a case in the SPSS data file and has scores on *K* variables, the scores obtained on the measure by the participants within a set.

If the independent variable has only two occasions or conditions, no additional significance tests need to be conducted beyond the Friedman test. However, if a factor has more than two occasions or conditions and the overall test is significant, follow-up tests are usually conducted. These follow-up tests most frequently involve comparisons between pairs of group medians. For the Friedman test, we could use the Wilcoxon test to examine unique pairs.

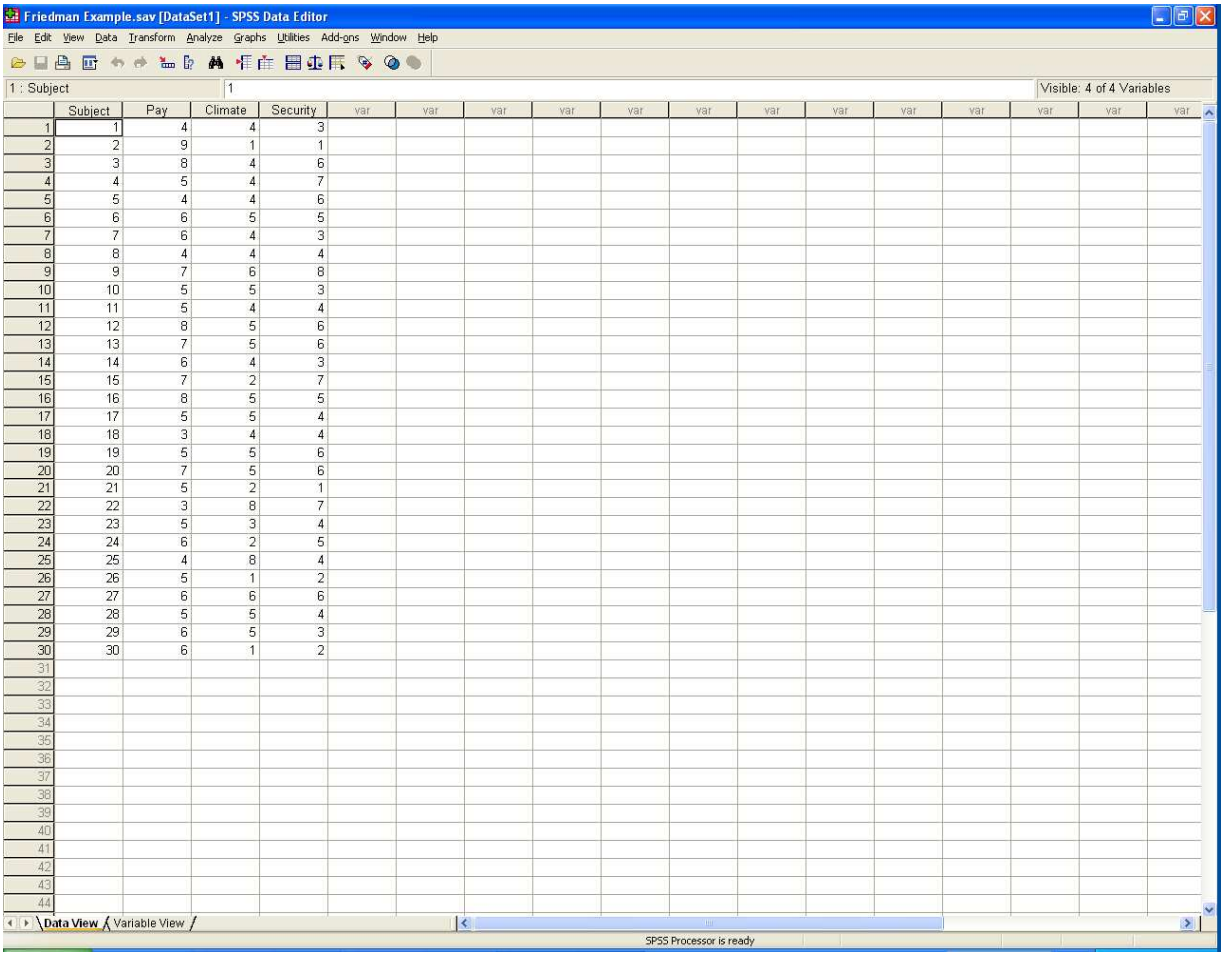
UNDERSTANDING THE FRIEDMAN TEST

For the Friedman test, the observations come in sets of *K* observations. Within a set, the observations are dependent, but between sets the observations are independent. For the Friedman test, the dependent variable must be measured on at least an ordinal scale, and the null hypothesis states that the population medians are equal for the *K* levels of a factor.

The parametric alternative to the Friedman test is the one-way repeated-measures analysis of variance (RM-ANOVA). For either test, analyses involve a factor with *K* levels, and we are interested in evaluating whether scores differ significantly across the levels of the factor. The tests take into account the dependency among scores introduced by the repeated-measures or matched-subjects characteristics of the design.

To help understand how the Friedman test evaluates differences in medians among conditions, we will look at an example provided by Green and Salkind (2008). First, we must describe what data are being analyzed in this test. We will be using an example dealing with concerns for job pay, climate, and security to demonstrate the Friedman test (Lesson 45 from Green & Salkind).

> For this example: **Pay** is defined as *concern for job pay on a rating scale from 1, indicating no concern, to 10, indicating ultimate concern*; **Climate** is defined as *concern for job climate on a rating scale from 1, indicating no concern, to 10, indicating ultimate concern*; and **Security**, which is defined as *concern for job security on a rating scale from 1, indicating no concern, to 10, indicating ultimate concern*.



	Subject	Pay	Climate	Security
1	1	4	4	3
2	2	9	1	1
3	3	8	4	6
4	4	5	4	7
5	5	4	4	6
6	6	6	5	5
7	7	6	4	3
8	8	4	4	4
9	9	7	6	8
10	10	5	5	3
11	11	5	4	4
12	12	8	5	6
13	13	7	5	6
14	14	6	4	3
15	15	7	2	7
16	16	8	5	5
17	17	5	5	4
18	18	3	4	4
19	19	5	5	6
20	20	7	5	6
21	21	5	2	1
22	22	3	8	7
23	23	5	3	4
24	24	6	2	5
25	25	4	8	4
26	26	5	1	2
27	27	6	6	6
28	28	5	5	4
29	29	6	5	3
30	30	6	1	2

ASSUMPTIONS UNDERLYING A FRIEDMAN TEST

Assumption 1: Each set of *K* observations must represent a random sample from a population and must be independent of every other set of *K* observations.

> If the data are from a repeated-measures design, the scores for each participant must be independent of the scores from any other participant. If the data are from a matched-subjects design, the sets of scores from any matched set of participants must be independent of the scores of any other matched set of participants. If the independence assumption is violated, the test is likely to yield inaccurate results. It should be noted that the analysis permits dependency among scores within a set.

Assumption 2: The Chi-Square values for the Friedman test yield relatively accurate results to the extent that the sample size is large.

> The results for the tests should be fairly accurate if the sample size is 30 or greater.

Assumption 3: The Distribution of the differences scores between any pair of levels is continuous and symmetrical in the population.

> This assumption is required to avoid ties and to ensure that the test evaluates difference in medians rather than other characteristics of the distribution.

EFFECT SIZE STATISTICS FOR THE FRIEDMAN TEST

SPSS computes Kendall's coefficient of concordance (Kendall's W), a strength-of-relationship index. The coefficient of concordance ranges from 0 to 1, with higher values indicating a stronger relationship.

THE RESEARCH QUESTION

The research question used in this example is asked to reflect differences in medians between conditions.

> Do employees' medians on concern for job pay, job climate, and job security ratings differ in the population?

CONDUCTING THE *K* RELATED-SAMPLES (FRIEDMAN) TEST IN SPSS

To conduct the Friedman test and follow-up tests using the Wilcoxon test in SPSS, use the following steps:

- Open the dataset in SPSS to be used for the Friedman Test analysis
- Click **Analyze**, click (mouse over) **Nonparametric Tests**, and then click **K Related Samples…**
    - You should now be in the Test for Several Related Samples dialog box
        - Click **Pay**, then holding down the Ctrl key, click **Climate**, and **Security**, and click ► to move them to the Test Variables: box
        - Under Test Type – be sure that Friedman is selected [√] – this should be the default
        - Under Test Type – select [√] Kendall's W
        - Click **Statistics**
            - Select [√] **Descriptive**
            - Click **Continue**
        - Click **OK**
- You are now ready to analyze the output data…

SPSS OUTPUT

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pay	30	5.67	1.493	3	9
Climate	30	4.20	1.750	1	8
Security	30	4.50	1.834	1	8

Friedman Test

Ranks

	Mean Rank
Pay	2.50
Climate	1.68
Security	1.82

Test Statistics[a]

N	30
Chi-Square	13.960
df	2
Asymp. Sig.	.001

a. Friedman Test

Kendall's W Test

Ranks

	Mean Rank
Pay	2.50
Climate	1.68
Security	1.82

Test Statistics

N	30
Kendall's W[a]	.233
Chi-Square	13.960
df	2
Asymp. Sig.	.001

a. Kendall's Coefficient of Concordance

The Friedman test, which evaluated differences in medians among the three job concerns, is significant $\chi^2(2, N = 30) = 13.96$, $p < .01$. Kendall's W is .23, indicating fairly strong differences among the three concerns.

Next, follow-up tests will need to be conducted to evaluate comparisons between pairs of medians. As indicated earlier, we will use the Wilcoxon test.

CONDUCTING PAIRWISE COMPARISONS AFTER OBTAINING A SIGNIFICANT FRIEDMAN TEST IN SPSS

To conduct the Wilcoxon test in SPSS, use the following steps:

- Click **Analyze**, click (mouse over) **Nonparametric Tests**, and then click **2 Related Samples…**
  - You should now be in the Two-Related Samples Tests dialog box
    - Holding down the Ctrl key, click **Pay** and **Climate**, and click ► to move them to the Test Pair(s) List: box
    - Holding down the Ctrl key, click **Pay** and **Security**, and click ► to move them to the Test Pair(s) List: box
    - Holding down the Ctrl key, click **Climate** and **Security**, and click ► to move them to the Test Pair(s) List: box
    - Under Test Type – be sure that Wilcoxon is selected [√] – this should be the default
    - Click **Options**
      - Under Statistics
        - Select [√] **Descriptive**
      - Click **Continue**
    - Click **OK**
- You are now ready to analyze the output data…

SPSS OUTPUT

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pay	30	5.67	1.493	3	9
Climate	30	4.20	1.750	1	8
Security	30	4.50	1.834	1	8

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Climate - Pay	Negative Ranks	19[a]	11.21	213.00
	Positive Ranks	3[b]	13.33	40.00
	Ties	8[c]		
	Total	30		
Security - Pay	Negative Ranks	20[d]	13.88	277.50
	Positive Ranks	6[e]	12.25	73.50
	Ties	4[f]		
	Total	30		
Security - Climate	Negative Ranks	10[g]	10.85	108.50
	Positive Ranks	13[h]	12.88	167.50
	Ties	7[i]		
	Total	30		

a. Climate < Pay

b. Climate > Pay

c. Climate = Pay

d. Security < Pay

e. Security > Pay

f. Security = Pay

g. Security < Climate

h. Security > Climate

i. Security = Climate

Test Statistics[c]

	Climate - Pay	Security - Pay	Security - Climate
Z	-2.822[a]	-2.626[a]	-.923[b]
Asymp. Sig. (2-tailed)	.005	.009	.356

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

The Least Significant Difference (LSD) procedure controls adequately for Type I error across pairwise comparisons if there are three levels and the overall test is significant. In our example, two of three comparisons (Climate-Pay and Security-Pay) were significant at the .05 alpha level. If the number of levels exceeds three, then the Bonferroni or Holm's Sequential Bonferroni method would be required to control adequately for Type I error.

APA RESULTS

Based on the results produced from the above example, the APA results would be:

A Friedman test was conducted to evaluate differences in medians among the job concerns for pay (Median = 5.50), for climate (Median = 4.00), and for security (Median = 4.00). The test was significant $\chi^2(2, N = 30) = 13.96$, $p < .01$, and the Kindall's coefficient of concordance of .23 indicated fairly strong differences among the three concerns.

Follow-up pairwise comparisons were conducted using a Wilcoxon test and controlling for the Type I errors across theses comparisons at the .05 level using the LSD procedure. The median concern for pay was significantly greater than the median concern for climate, $p < .01$, and the median concern for security, $p < .01$, but the median concern for climate did not differ significantly from the median concern for security $p = .356$.

* The following Statistics Table would be needed to write the above results… this is obtained by clicking on Analyze, clicking Descriptive Statistics… and then clicking Frequencies. Select the variable and request their Median under the Statistics option.

Statistics

		Pay	Climate	Security
N	Valid	30	30	30
	Missing	0	0	0
Median		5.50	4.00	4.00

REFERENCE

Green, S. B., & Salkind, N. J. (2008). *Using SPSS for Window and Macintosh: Analyzing and understanding data* (5th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.