22S:30/105 Statistical Methods and Computing

More on Nonparametric Methods

Lecture 26
April 22, 2011

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The Wilcoxon Signed-Rank Test

- for single sample or paired samples
- useful when the population distribution is not normal and the sample size is not large
  - of the within-pair differences in paired sample case or of individual values in single sample case
- makes use of the magnitudes of the differences as well as their signs

Example

(Example 26.1 from online chapter of textbook)

Does the presence of small numbers of weeds reduce the yeild of corm? Lamb's quarter is a common weed in corn fields. A researcher planted corn at the same rate in 8 small plots of ground, then weeded the corn rows by hand to allow no weeds in 4 ramdomselected plots and exactly 3 lambs's quarter plants per meter of row in the other 4 plots.

We will test the hypothesis that there is no difference against the one-sided hypothesis that yields are higher when no weeds are present. We will use significance level alpha = .10.


```
data weeds ;
input weeds yield ;
datalines ;
0 166.7
0 172.2
0 165.0
0 176.9
3 158.6
3 176.4
3 153.1
3 156.4
;
run ;

proc sort data = weeds ;
by weeds ;
run ;

proc univariate plot data = weeds ;
by weeds ;
var yield ;
run ;


proc npar1way  wilcoxon ;
```

5

```
class weeds ;
var yield ;
run ;
```

6

```
weeds = 0

           Stem Leaf                     #
            176 9                        1
            174
            172 2                        1
            170
            168
            166 7                        1
            164 0                        1
                ----+----+----+----+


weeds = 3

           Stem Leaf                     #
              17 6                       1
              17
              16
              16
              15 69                      2
              15 3                       1
                 ----+----+----+----+
            Multiply Stem.Leaf by 10**+1
```

7

The NPAR1WAY Procedure

Wilcoxon Scores (Rank Sums) for Variable yield
Classified by Variable weeds

weeds	N	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
0	4	23.0	18.0	3.464102	5.750
3	4	13.0	18.0	3.464102	3.250

Wilcoxon Two-Sample Test

Statistic	23.0000
Normal Approximation	
Z	1.2990
One-Sided Pr > Z	0.0970
Two-Sided Pr > |Z|	0.1939
t Approximation	
One-Sided Pr > Z	0.1175
Two-Sided Pr > |Z|	0.2351

Z includes a continuity correction of 0.5.

8

Interpreting the results

We are interested in the one-sided test, since our alternative hypothesis is that median yield is larger when there are no weeds.

Our significance level is .10. Note that the two versions of the test carried out by SAS give different conclusions: the p-value for the z approximation is .0970, so we would reject the null hypothesis and conclude that yields are higher when there are no weeds. However, the p-value with the t approximation is $0.1175 > 0.10$, so we would not be able to reject.

The Wilcoxon Signed-Rank Test

- for single sample or paired samples
- useful when the population distribution is not normal and the sample size is not large
  - of the within-pair differences in paired sample case or of individual values in single sample case
- makes use of the magnitudes of the differences as well as their signs
- can be used to test the null hypothesis that the variable has the same distribution in both populations versus the alternative that values of the variable are systematically higher in one population versus the other

Example 26.6 from the textbook

A study of eary childhood education asked kindergarten children to tell fairy tales that had been read to them earlier in the week. Each child told two stories. THe first one had been read to them and no pictures had been shown. The second story was read and also illustrated with pictures. An expert listened to a recording of the children and assigned a score for certain uses of language. We wish to use the data to determine whether using illustrations during reading improves how children retell stories.

	Child				
	1	2	3	4	5
Story 2	0.77	0.49	0.66	0.28	0.38
Story 1	0.40	0.72	0.00	0.36	0.55
Difference	0.37	-0.23	0.66	-0.08	-0.17

This is a matched pairs design. We will apply the Wilcoxon signed rank test to the differences.

We can use `proc univariate` to simultaneously do a paired t-test, a Wilcoxon signed rank test, and a sign test. The Wilcoxon signed rank test is the best choice. The sample size is so small that we can't really check whether the assumptions behind the paired t test are met. The sign test wastes the quantitative information in the data.


```
data stories ;
input story2 story1 ;
diff = story2 - story1 ;
datalines ;
0.77 0.40
0.49 0.72
0.66 0.00
0.28 0.36
0.38 0.55
;
run ;

proc univariate data = stories ;
var diff ;
run ;
```

```
                Tests for Location: Mu0=0

Test           -Statistic-    -----p Value------

Student's t    t  0.634979    Pr > |t|    0.5599
Sign           M      -0.5    Pr >= |M|   1.0000
Signed Rank    S       1.5    Pr >= |S|   0.8125
```

The p-value for the two-sided Wilcoxon signed rank test is 0.8125. Even if we divide it by two since our alternative hypothesis is one-sided, we get $p = 0.4063$. Based on this data, we cannot reject the null hypothesis. The data does not provide enough evidence for us to conclude that showing pictures while reading stories to kindergarteners improves the kids' retelling of the stories.