

## 22S:30/105, Statistical Methods and Computing

Instructor: Cowles  
Lab 7, April 22, 2009  
One-way ANOVA  
Inference in Regression

### 1 Downloading datasets

Download the following data files from the course web page:

```
autistic.dat  
hotdogs.dat  
OECD.dat
```

### 2 Immunology

(example taken from Daniel *Biostatistics: A Foundation for Analysis in the Health Sciences*)

Research by Singh et al. (1999) as reported in the journal *Clinical Immunology and Immunopathology* is concerned with immune abnormalities in autistic children. As part of their research, they took measurements on the serum concentration of an antigen in three samples of children, autistic children, normal children, and mentally-handicapped children (non-Down's-syndrome). All children were 10 years old or younger.

This dataset contains two variables:

```
concentration of the antigen (in units per milliliter of serum)  
group,      coded A for autistic  
             N for normal  
             M for mentally handicapped
```

1. What population(s) do the researchers wish to study?
2. If the researchers believed that the distributions of serum concentrations of this antigen were normal in each of the populations of interest, what additional assumption would be needed to justify the use of one-way ANOVA to analyze these data?
3. What is the null hypothesis?
4. What is the alternative hypothesis?

5. Read the dataset into SAS:

```
options linesize = 75 ;  
  
data autistic ;  
infile 'c:\temp\autistic.dat' ;  
input conc group $ ;  
run ;  
P
```

6. Use SAS to check the assumptions of one-way ANOVA.

```
proc sort data = autistic ;  
by group ;  
run ;  
  
proc univariate plot data = autistic ;  
var conc ;  
by group ;  
run ;  
  
proc means data = autistic ;  
var conc ;  
by group ;  
run ;
```

- (a) Do the distributions of the sample data appear to be roughly normal?
- (b) Is the largest sample standard deviation no more than twice as large as the smallest sample standard deviation?

### 3 Food

The "hotdogs" dataset contains data on the sodium and calories contained in each of 54 major hotdog brands. The variables are:

```
type -- Beef, Meat, or Poultry  
calories per hotdog  
sodium per hotdog
```

There are many other brands of hotdogs on the market besides those included in this dataset. We are interested in determining whether the mean number of calories per hotdog is the same in all of the three types of hotdogs.

1. What population(s) do we researchers wish to study?

2. What is the null hypothesis?

3. What is the alternative hypothesis?

4. Read the dataset into SAS:

```
data hotdogs ;  
infile 'c:\temp\hotdogs.dat' ;  
input type $ calories sodium ;  
run ;
```

5. Use SAS to check the assumptions of one-way ANOVA.

```
proc sort data = hotdogs ;  
by type ;  
run ;  
  
proc univariate plot data = hotdogs ;  
var calories ;  
by type ;  
run ;  
  
proc means data = hotdogs ;  
var calories ;  
by type ;  
run ;
```

(a) Do the distributions of the sample data appear to be roughly normal?

(b) Is the largest sample standard deviation no more than twice as large as the smallest sample standard deviation?

6. Use SAS to test your hypotheses at the  $\alpha = .05$

```
proc anova data = hotdogs ;  
class type ;  
model calories = type ;  
run ;
```

The SAS output is as follows:

```
                The ANOVA Procedure  
                Class Level Information  
                Class          Levels  Values  
                type              3    Beef Meat Poultry  
  
                Number of observations    54  
  
Dependent Variable: calories  
  
                Sum of  
Source          DF          Squares  Mean Square  F Value  Pr > F  
Model            2    17692.19510    8846.09755    16.07  <.0001  
Error            51    28067.13824     550.33604  
Corrected Total  53    45759.33333  
  
                R-Square    Coeff Var    Root MSE    calories Mean  
                0.386636    16.12935    23.45924     145.4444  
  
Source          DF          Anova SS  Mean Square  F Value  Pr > F  
type            2    17692.19510    8846.09755    16.07  <.0001
```

7. Can we reject the overall hypothesis of equality of means?

8. Are we justified in carrying out pairwise t-tests to look for significant differences between individual pairs of means?

9. Add a "means" statement to carry out the pairwise t-tests with Bonferroni correction.

```
proc anova data = hotdogs ;  
class type ;  
model calories = type ;  
means type / bon alpha = .05 ;  
run ;
```

The new part of the output is:

The ANOVA Procedure  
Bonferroni (Dunn) t Tests for calories

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	51
Error Mean Square	550.336
Critical Value of t	2.47551

Comparisons significant at the 0.05 level are indicated by \*\*\*.

type Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
Meat - Beef	1.856	-17.302	21.013	
Meat - Poultry	39.941	20.022	59.860	***
Beef - Meat	-1.856	-21.013	17.302	
Beef - Poultry	38.085	18.928	57.243	***
Poultry - Meat	-39.941	-59.860	-20.022	***
Poultry - Beef	-38.085	-57.243	-18.928	***

10. Which population means are significantly different at the .05 level?

#### 4 International health economics

Reference: <http://www.oecd.org/publications/figures/>

The OECD dataset is collated from the above web page of the Organization for Economic Cooperation and Development (OECD). It provides summary statistics for the 29 member nations. The variables are as follows:

name: name of country  
pcgdp: per capita gross domestic product (1998)  
reported in US dollars converted using Purchasing Power Parities to  
adjust for differences in price levels between countries  
pch: per capita health care expenditures (1996)  
reported in US dollars converted using Purchasing Power Parities  
beds: in-patient hospital beds per 1000 population (1996)

los: average length of stay in days for hospital patients (1996)  
docs: doctors per 1000 population (1996)  
infmort: infant mortality (1996)  
number of deaths of infants < 1 yr of age per 1000 live births  
region: region of the world

Suppose we want to get predicted values of pch if we know pcgdp. We want predicted values for the countries that are in the dataset, as well as for a hypothetical new country with pcgdp = \$20,000.

We will put a dummy record in the dataset with a missing value for pch and the desired value of the explanatory variable. This record will not be included in SAS's calculation of the regression coefficients, but SAS will give us predicted values, as well as a confidence interval and prediction interval, for it. SAS's symbol for a missing value is a period.

```
*****
* Reading in *
* the dataset *
***** ;

data OECD ;
infile 'c:\temp\OECD.dat' ;
input name $13. pcgdp pch beds los doc infmort region $ ;
run ;

*****
* Checking *
***** ;

* Note the extra record with missing value for pch ;

proc print data = OECD ;
run ;

*****
* Regression *
***** ;

proc reg data = OECD ;
model pch = pcgdp / clb ;
run ;

*****
```

```

* Predicted values *
* and residuals   *
***** ;

proc reg data = OECD ;
model pch = pcgdp / p ;
id name ;
run ;

*****
* Confidence limits *
* for means of sub- *
* populations      *
***** ;

proc reg data = OECD ;
model pch = pcgdp / clm ; /* clm gets conf limits for the mean */
id name ;
run ;

*****
* Prediction limits *
* for individual   *
* predictions      *
***** ;

proc reg data = OECD ;
model pch = pcgdp / cli ; /* cli gets prediction interval for
                           new individual */
id name ;
run ;

*****
* Scatterplots and *
* Residual plots   *
***** ;

proc reg data = OECD ;
model pch = pcgdp / p ;
plot pch * pcgdp / symbol = '.' ;
run ;
plot residual. * predicted. / symbol = '.' ;
run ;

```

feature in SAS called "Insight."

Scatterplots and residual plots may also be obtained easily using the automated