CSC324/423 Data Analysis and Statistical Software II

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SAS Procedures for the inference on averages

PROC MEANS

The **PROC Means** provides data summarization tools to compute descriptive statistics for variables across all observations and within groups of observations. For example, it calculates the descriptive statistics based on moments, estimates the percentiles and the median value, calculates the confidence limits for the mean and performs a **t** test on the population average.

PROC MEANS DATA=*dataset-name* <*statistic-keyword(s)*>;
VAR *variables*; ← one or more measurement variables in the dataset
RUN;

The **statistics keywords** specify which statistics to compute and the order to display them in the output.
The available keywords in the PROC statement include: MEAN (average), STD (standard deviation), STDERR (standard error), P50 (median), Q1 (first quartile), Q3 (third quartile).
Keywords for confidence intervals: CLM, ALPHA=*value* specifies the confidence level (1-*value*)%
Keywords for t-tests: T (t-statistic), PRT (p-value). Notice that SAS provides a test only for a zero population average, i.e. H0: μ=0.

PROC UNIVARIATE

The **PROC Univariate** computes several descriptive statistics, including the mean, the median, the percentiles, the standard deviation, min, max, etc. The list below includes some statements that can be used with the UNIVARIATE procedure.

PROC UNIVARIATE DATA=*dataset-name*;		
BY <DESCENDING> *variable-1* <NOTSORTED>;	←	Calculate separate statistics for each BY group
VAR *variables*;	←	Select the analysis variables and determine their order in the report. Variables are one or more measurement variables in the dataset
ID *id-variable*;	←	If used, it is the name of one variable used to identify the extreme observations
HISTOGRAM / normal cfill=WHITE pfill=SOLID name='HIST';	←	Create a high-resolution graph of a histogram / OPTIONS: normal is an option to fit the normal distribution and draw the normal density on the graph; cfill, pfill control the appearance of the histogram.
PROBPLOT / normal (mu=est sigma=est color=BLUE l=**1** w=**1**);	←	Create a high-resolution graph of a normal probability plot.
OUTPUT <OUT=*SAS-data-set*> *statistic-keyword-l =name(s);*	←	Create an output data set that contains specified statistics

EXAMPLE

Consider the following data set on the time between machine failures. Data were collected during a study on machine performance that involved 39 similar machines. The producing company states that on average the time between failures is 20 hours. The researchers believe that on average the time between failures is longer than 20 hours, so they want to estimate the average time between failures and test the claim of the producing company.

DATA: 21.6 21.7 22.7 21.2 21.9 21.6 24.8 22.5 21.9 23.6 23.0 22.3 23.3 24.2 25.5 22.5 23.1 24.7 26.2 24.7 23.6 21.5 23.7 24.3 26.2 22.5 22.7 21.5 24.3 24.7 25.7 27.3 22.4 20.1 26.3 23.9 21.7 23.3 22.2

STEP 1 – Read the data into SAS and create the SAS data set "failure"

```
Title 'Time between failures';

data failure;
infile "c:/…/faildata.dat";
input time;
timecent=time-20;
label time = 'time between failures' timecent = time-20 hours;
```

STEP 2 – Compute some descriptive statistics about the data and a 95% confidence interval for the average time between failures.

```
proc means mean std stderr clm p25 p50 p75;
var time;
run;
```

```
                    Time between failures
                     The MEANS Procedure

        Analysis Variable : time time between failures
                                            Lower 95%      Upper 95%
     Mean         Std Dev     Std Error    CL for Mean    CL for Mean
-------------------------------------------------------------------
23.3564103     1.6676165     0.2670323     22.8158315     23.8969890
-------------------------------------------------------------------
        Analysis Variable : time time between failures

          25th Pctl      50th Pctl        75th Pctl
      -----------------------------------------------
         21.9000000     23.1000000       24.7000000
      -----------------------------------------------
```

The estimated average time between failures is 23.3564103 hours, with standard error equal to 0.267 hours. The average time is between 22.81 hours and 23.9 hours.

STEP 3 – Test the company's claim that the average time between failures is 20 hours.
Null hypothesis: **Ho: μ=20** hours against the alternative hypothesis that **Ha: μ > 20 hours.**
To use SAS, we need to compute the variable timecent=time-20 and express the test as:
Ho: μ=0 vs Ha: μ>0 where μ is now the population average for the new variable timecent.
Note: Examine the data histogram and the normal probability plot to check the normality assumptions, before carrying out the statistical test.

```
proc univariate normal;
var timecent;
histogram /cfill=WHITE pfill=SOLID name='HIST' normal;
probplot/normal(mu=est sigma=est color=BLUE l=1 w=1);
run;
```

```
                    The UNIVARIATE Procedure
                Variable:  timecent  (time-20 hours)

                            Moments
    N                          39    Sum Weights                 39
    Mean               3.35641026    Sum Observations         130.9
    Std Deviation      1.66761646    Variance            2.78094467
    Skewness           0.47112614    Kurtosis            -0.3745406
    Uncorrected SS         545.03    Corrected SS        105.675897
    Coeff Variation    49.6845241    Std Error Mean      0.26703235

                  Basic Statistical Measures
            Location                    Variability
        Mean     3.356410     Std Deviation            1.66762
        Median   3.100000     Variance                 2.78094
        Mode     2.500000     Range                    7.20000
                              Interquartile Range      2.80000
 NOTE: The mode displayed is the smallest of 2 modes
     with a count of 3.

                  Tests for Location: Mu0=0

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

           Student's t    t   12.5693    Pr > |t|    <.0001
           Sign           M      19.5    Pr >= |M|   <.0001
           Signed Rank    S       390    Pr >= |S|   <.0001
```

RESULT: The t test is highly significant, since the p-value is very small (<.0001/2=.00005). Thus the data do not support the company's claim and are consistent with the researchers' hypothesis. Note that the t-statistic is positive and very large, indicating that the actual time between failures is sensibly larger than 20 hours.

Tests for Normality

Test	Statistic		p Value	
Shapiro-Wilk	**W**	**0.965106**	**Pr < W**	**0.2628**
Kolmogorov-Smirnov	**D**	**0.114608**	**Pr > D**	**>0.1500**
Cramer-von Mises	W-Sq	0.078669	Pr > W-Sq	0.2166
Anderson-Darling	A-Sq	0.512045	Pr > A-Sq	0.1921

Quantiles (Definition 5)

Quantile	Estimate
100% Max	7.3
99%	7.3
95%	6.3
90%	6.2
75% Q3	4.7
50% Median	3.1
25% Q1	1.9
10%	1.5
5%	1.2
1%	0.1
0% Min	0.1

Extreme Observations

Lowest		Highest	
Value	Obs	Value	Obs
0.1	34	5.7	31
1.2	4	6.2	19
1.5	28	6.2	25
1.5	22	6.3	35
1.6	6	7.3	32

Parameters for Normal Distribution

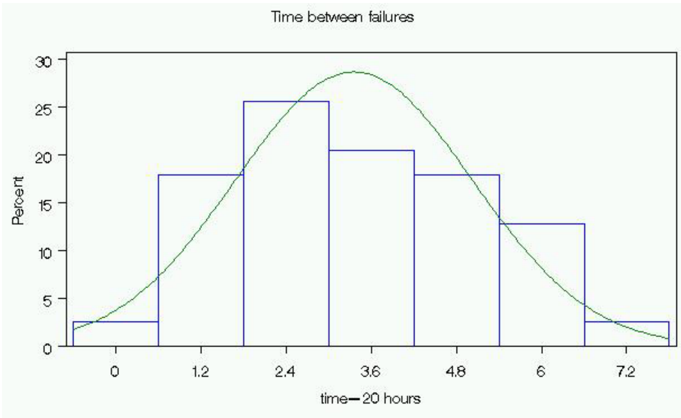
Parameter	Symbol	Estimate
Mean	Mu	3.35641
Std Dev	Sigma	1.667616

Goodness-of-Fit Tests for Normal Distribution

Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.11460833	Pr > D	>0.150
Cramer-von Mises	W-Sq	0.07866879	Pr > W-Sq	0.217
Anderson-Darling	A-Sq	0.51204470	Pr > A-Sq	0.192

The Shapiro-Wilk test supports the assumption that the data arise from a normal population. The normal probability plot confirms this result, because the points lie close to a line. The histogram, however, is skewed. We assume that data come from a normally distributed population and we use the t-test. Notice that both the sign test and the t test produce the same result.

Histogram of the data



Normal probability plot