Hypothesis Testing In Minitab

Revision 130110

Comparisons of single factor data sets (NOT paired like X-Y; $X\text{-}X_2$-Y; or Input-Output data)

Data Type	Measure	# of Samples (levels)	Distribution: Normal (AD>0.05)	Distribution: Not-normal (AD<0.05)*	Exceptions
Continuous (Variable)	Center (Mean or Median)	1 sample (level)	**1-sample t-test** (robust against normality assumption) (Use z-test for samples >30) **Stat>Basic Statistics>1-Sample t-test** **or** **Stat>Basic Statistics>1-Sample z-test**	**1-sample Wilcoxon** (assumes symmetry (symmetric boxplot or, more liberally, w/o outliers)) **Stat>Nonparametrics>1-Sample Wilcoxon**	Assymmetric distribution / outliers?: **1-sample Sign** **Stat>Nonparametrics>1-Sample Sign**
		2 samples (levels)	Paired data? See Exception --->**2-sample t-test** (Use F-test to determine if Variances are equal; if not equal, do not assume equal variances) **Stat>Basic Statistics>2-Sample t**	Paired data? See Exception --->Assumes same shape (Visual) & equal variance (2 Variances test) **Stat>Basic Statistics>2 Variance Test** **2-sample Mann-Whitney** **Stat>Nonparametrics>Mann-Whitney**	**Paired Data?** Both paired data sets Normally distributed? **Paired t-test**** (extremely robust against assumptions of normality, shape, and differences in variance. May be used as a non-parametric test) **Stat>Basic Statistics>Paired t**
		3 or more samples (levels)	**ANOVA (plus Tukey)** (robust against normality and equal variances, but recommend checking) **Stat>ANOVA>One-way** **- Select Tukeys comparisons**	**Kruskal-Wallis** (assumes non-normal (AD<0.05), no outliers (Boxplot), same shape (Visual) **Stat>Nonparametrics>Kruskal-Wallis** Note: Based on poisson distribution but works for continuous data	Not normal (AD>0.05) and includes outliers (boxplot)? **Mood's Median** (Assumes same shape (visual / boxplot)) **Stat>Nonparametrics>** **Mood's Median test** Note: Based on poisson distribution but works for continuous data
	Spread (Variance or standard deviation)	1 sample (level)	**Chi-Square Method** **Stat>Basic Statistics>1 Variance** (read p-value from "chi square method")	**Bonett Method** **Stat>Basic Statistics>1 Variance** (read p-value from "Bonett method")	
		2 samples (levels)	**F-test** **Stat>Basic Statistics>2 Variances** (read p-value from F-test)	**Levene's test** **Stat>Basic Statistics>2 Variances** (read p-value from Levene's test)	
		3 or more samples (levels)	**Bartlett's test** **Stat>ANOVA>Test for Equal Variances** (read p-value from Bartlett's test)	**Levene's test** **Stat>ANOVA>Test for Equal Variances** (read p-value from Levene's test)	
Discrete (Attribute) (Poisson / Count / Ordinal / Defects)	Count	1 sample (level)	**1-sample t-test** (robust against normality assumption) (requires > 5 distinct categories) **Stat>Basic Statistics>1-Sample t-test** **or** **Stat>Basic Statistics>1-Sample z-test**	**1-sample Wilcoxon** (assumes symmetry (symmetric boxplot or, more liberally, w/o outliers), requiers > 5 distinct categories. **Stat>Nonparametrics>1-Sample Wilcoxon**	Assymmetric distribution / outliers? Fewer than 5 distinct categories? No problem! **1-sample Sign** **Stat>Nonparametrics>1-Sample Sign**
		2 samples (levels)	Paired data? See "Exception" --->**2 Sample t-test** (Caution: No extreme outliers! **(Graph>Box Plot)** **Stat>Basic Stats>2-sample Poisson Rate** Based on continuous distribution, but appropriate for poisson data	Paired data? See "Exception" --->Same shape & Variance? **2-sample Mann-Whitney** **Stat>Nonparametrics>Mann-Whitney** Different shape or Variance? Hmmm….	**Paired Data?** Normal data not required Same shape not required Same variance not required **Paired t-test**** (robust against normality, shape, and differences in variance) **Stat>Basic Statistics>Paired t**
		3 or more samples (levels)	**One-Way ANOVA** Caution: No extreme outliers! Check boxplot) **Stat>ANOVA>One-way** Note: One-way ANOVA presumes one X factor with 3 or more levels. Rarely, we may have two X factors, where at least one of the factors has at least three factors. In these cases, use Two-way ANOVA or DOE.	**Kruskal-Wallis** Assumes no outliers (check boxplot) Assumes same shape (visual check) **Stat>Nonparametrics>** **Kruskal-Wallis** Note: This is a Poisson distribution test often used for non-normal continuous data without outliers	Includes outliers? No problem! **Mood's Median** Robust against outliers Assumes same shape **Stat>Nonparametrics>** **Mood's Median test** Note: This is a Poisson distribution test often used for non-normal continuous data with outliers
Discrete (Attribute) (Binomial / go/no-go / defective)	Proportion	1 sample (level)	**1-Proportion test** **Stat>Basic Statistics>1-Proportion**		
		2 samples (levels)	**2-Proportion test** **Stat>Basic Statistics>2-Proportion** **- Select Options>pooled p**		
		3 or more samples (levels)	**Chi-Square test** **Stat>Tables>Chi-square Goodness of Fit Test (one variable)**		

Comparisons of data from two or more factors (paired like X-Y'; X1-X2-Y'; Input-Output data, etc.)

	Continuous Data (X, Input(s), or Independent Factor(s))	Discrete Data (X, Input(s), or Independent Factor(s))
Continuous Data (Y, Output, or Dependent Factor)	**Regression** **Stat>Regression>Regression** or Design of Experiments (**DOE**)*** **Stat>DOE>Create Factorial Design**	**2-Way ANOVA** **(2 factors, 3 or more discrete sources or levels on at least one)** **Stat>ANOVA>Two-way** **Design of Experiments (DOE)***** **(2 or more X's, at least two distinct levels for each factor)** **Stat>DOE>Create Factorial Design**
Discrete Data (Y, Output, or Dependent Factor)	**Logistic Regression** Determine Discrete data type, then: **Stat>Regression>Binary (or Ordinal, or Nominal) Logistic Regression**	**Chi-Square (Test for Association)** "Is Y independent of X?" **Stat>Tables>Chi-square test (Two Way Table in Worksheet)** Note: which variable is "Y" and which is "X" does not matter.

Hypothesis Tests - *Null and Alternate Hypothesis Statements*

Normal Probability Plot
- H_0 = Data are normal
- H_a = Data not normal

Anderson-Darling Test for Normality (Descriptive Statistics)
- H_0 = Data are normal
- H_a = Data not normal

t-test
- H_0 = The mean of the sample distribution is the same as the reference mean
- H_a = The means are not equal

One-way ANOVA
- H_0 = There is no difference between the Means
- H_a = There is at least one mean different from the others

Two-way ANOVA
- H_0 = There is no difference between the Means
- H_a = There is at least one mean different from the others

Balanced ANOVA/General Linear Model
- H_0 = The factor has no effect on the Response
- H_a = The factor does have an effect on the Response

Mood's Median Test (Non-parametrics)
- H_0 = Medians are equal
- H_a = At least one median is different from the others d

Kruskal-Wallis Test (Non-parametrics)
- H_0 = Medians are equal
- H_a = At least one median is different from the others

Chi-Square
- H_0 = There is no relationship between the variables
- H_a = There is a relationship between the variables

Correlation
- H_0 = There is no correlation between the variables
- H_a = There is correlation between the variables

Regression Analysis

Simple Regression
- H_0 = Coefficient is equal to zero
- H_a = Coefficient is not equal to zero

Multiple Regression
- H_0 = All coefficients, except b_0 are equal to zero
- H_a = All coefficients are not equal to zero

or...
- H_0 = The slope of the line is equal to zero
- H_a = The slope of the line is not equal to zero

Test for Equal Variances
- H_0 = The variances are equal
- H_a = At least one variance is different

Normal data: Use F-Test orBartlett's Test
Non-normal data: Use Levene's Test

* For continuous data with "large" sample size (n>30), it is statistically valid to assume normality for statistical tests of mean due to the Central Limit Theorem.
In the Army MBB POI, we do not use this application of the CLT because we are not interested in the mean of non-normal data -- we are interested in the median.
For Army MBB exam, if the sample(s) do not show AD Normality test p>0.05, use the designated non-parametric test, regardless of sample size.

** The Paired t-test has been validated as a non-parametric test, and can be used with non-normal paired continuous and poisson data

*** Design of Experiments (DOE) requires continous / variable *output* data, but *input* data may be continuous, count, binomial, or even nominal.
Two key things to remember about DOE.
1) Each input factor must be divided into two or more distinct "levels" 2) DOE (2-way ANOVA) is the only tool that allows us to evaluate *interactions* for statistical significance.