New Stata 7 Commands for Computing p-Values and Critical Values of t and F Statistics

Stata for Windows Release 7 includes new commands for computing both p-values of t and F statistics and critical values of t and F distributions. This memo presents a very brief summary of these new commands.

❑ Computing critical values of t-distributions and p-values for t-statistics

Basic Syntax: The new *Stata 7* statistical functions for the t-distribution are **ttail(*df, t₀*)** and **invttail(*df, p*)**. The new *Stata 7* function **ttail(*df*, t_0)** replaces the **tprob(*df*, t_0)** function of previous releases, and in many ways is easier to use. Similarly, the new *Stata 7* function **invttail(*df*, t_0)** replaces the **invt(*df*, t_0)** function of previous releases.

- **ttail(*df*, t_0)** computes the ***right-tail* (upper-tail) p-value of a t-statistic** that has degrees of freedom ***df*** and calculated sample value t_0. It returns the probability that $t > t_0$, i.e., the value of $\Pr(t > t_0)$.

- **invttail(*df, p*)** computes the ***right-tail* critical value of a t-distribution** with degrees of freedom ***df*** and ***probability level p***. Let α denote the chosen significance level of the test. For two-tail t-tests, set $p = \alpha/2$. For one-tail t-tests, set $p = \alpha$.

- If **ttail(*df*, t_0)** = ***p***, then **invttail(*df, p*)** = t_0.

Usage: The statistical functions **ttail(*df*, t_0)** and **invttail(*df, p*)** must be used with *Stata 7* commands such as **display**, **generate**, **replace**, or **scalar**; they cannot be used by themselves. For example, simply typing **ttail(60, 2.0)** will produce an error message. Instead, to obtain the right-tail p-value for a calculated t-statistic that equals 2.0 and has the t-distribution with 60 degrees of freedom, enter the **display** command:

```
display ttail(60, 2.0)
```

Examples: Suppose that sample size N = 63 and K = 3, so that the degrees of freedom for t-tests based on a linear regression with three regression coefficients equal N − K = N − 3 = 60.

Example 1: Two-tail t-tests

- The following are the ***two-tail*** **critical values $t_{\alpha/2}[60]$** of the t[60] distribution, where α is the chosen significance level for the two-tail t-test; they are taken from a published table of percentage points of the t distribution.

  $\alpha = 0.01 \Rightarrow \quad \alpha/2 = 0.005: \quad t_{\alpha/2}[60] = t_{0.005}[60] = 2.660;$
  $\alpha = 0.02 \Rightarrow \quad \alpha/2 = 0.01: \quad t_{\alpha/2}[60] = t_{0.01}[60] = 2.390;$
  $\alpha = 0.05 \Rightarrow \quad \alpha/2 = 0.025: \quad t_{\alpha/2}[60] = t_{0.025}[60] = 2.000;$
  $\alpha = 0.10 \Rightarrow \quad \alpha/2 = 0.05: \quad t_{\alpha/2}[60] = t_{0.05}[60] = 1.671.$

- The following commands use the **invttail(*df, p*)** statistical function to display these ***two-tail*** **critical values of the t[60] distribution** at the four chosen significance levels α, namely α = 0.01, 0.02, 0.05, and 0.10:

  display invttail(60, 0.005)
  display invttail(60, 0.01)
  display invttail(60, 0.025)
  display invttail(60, 0.05)

```
. display invttail(60, 0.005)
2.660283
. display invttail(60, 0.01)
2.3901195
. display invttail(60, 0.025)
2.0002978
. display invttail(60, 0.05)
1.6706489
```

- Now use the **ttail(*df, t₀*)** statistical function to display the ***two-tail* p-values** of the four sample values t_0 = 2.660, 2.390, 2.000, and 1.671, which you already know equal the corresponding values of α (0.01, 0.02, 0.05, and 0.10):

  display 2*ttail(60, 2.660)
  display 2*ttail(60, 2.390)
  display 2*ttail(60, 2.000)
  display 2*ttail(60, 1.671)

  Note that to compute the ***two-tail* p-values** of the calculated t-statistics, the values of the **ttail(*df*, t_0)** function must be multiplied by 2.

```
. display 2*ttail(60, 2.660)
.0100075
. display 2*ttail(60, 2.390)
.02000593
. display 2*ttail(60, 2.000)
.05003304
. display 2*ttail(60, 1.671)
.0999303
```

  This example demonstrates the relationship between the two statistical functions **ttail(*df*, t_0)** and **invttail(*df, p*)** for the t-distribution.

- Suppose the sample t-values are *negative*, rather than *positive*. For example, consider the sample t-values t_0 = −2.660, and −2.000; you already know that their two-tail p-values are, respectively, 0.01, and 0.05. There are (at least) two alternative ways of using the **ttail(*df*, t_0)** statistical function to compute the correct ***two-tail* p-values** for negative values of t_0. To illustrate, enter the following **display** commands:

  display 2*(1 - ttail(60, -2.660))
  display 2*ttail(60, abs(-2.660))

  display 2*(1 - ttail(60, -2.000))
  display 2*ttail(60, abs(-2.000))

  Note the use of the *Stata* absolute value operator **abs( )**.

```
. display 2*(1 - ttail(60, -2.660))
.0100075
. display 2*ttail(60, abs(-2.660))
.0100075

. display 2*(1 - ttail(60, -2.000))
.05003304
. display 2*ttail(60, abs(-2.000))
.05003304
```

- **General recommendation for computing *two-tail* p-values of t-statistics**

  Let ***t0*** be any calculated sample value of a t-statistic that is distributed under the null hypothesis as a **t[*df*]** distribution, where ***t0*** may be either positive or negative.

  The following command will always display the correct ***two-tail*** **p-value of *t0***:

  display 2*ttail(*df*, abs(*t0*))

- ***Example 2: One-tail t-tests -- right-tail t-tests***

- The following are the ***upper one-tail (right-tail)*** **critical values $t_{\alpha}[60]$** of the t[60] distribution, where α is the chosen significance level for the one-tail t-test; they are taken from a published table of percentage points of the t distribution.

  $\alpha = 0.01$: $t_{\alpha}[60] = t_{0.01}[60] = 2.390$;
  $\alpha = 0.05$: $t_{\alpha}[60] = t_{0.05}[60] = 1.671$;
  $\alpha = 0.10$: $t_{\alpha}[60] = t_{0.10}[60] = 1.296$.

- The following commands use the **invttail(*df, p*)** statistical function with $p = \alpha$ to display these ***upper one-tail (right-tail)*** **critical values of the t[60] distribution** at the 1%, 5% and 10% significance levels, i.e., for α = 0.01, 0.05 and 0.10:

  display invttail(60, 0.01)
  display invttail(60, 0.05)
  display invttail(60, 0.10)

```
. display invttail(60, 0.01)
2.3901195
. display invttail(60, 0.05)
1.6706489
. display invttail(60, 0.10)
1.2958211
```

- Now use the **ttail(*df, t₀*)** statistical function to display the ***right-tail*** **p-values** of the sample t-values t_0 = 2.390, 1.671, and 1.296, which you already know equal the corresponding values of α, namely 0.01, 0.05, and 0.10, respectively:

  display ttail(60, 2.390)
  display ttail(60, 1.671)
  display ttail(60, 1.296)

```
. display ttail(60, 2.390)
.01000296
. display ttail(60, 1.671)
.04996515
. display ttail(60, 1.296)
.09996938
```

Example 3: One-tail t-tests -- left-tail t-tests

- The following are the ***lower one-tail (left-tail)*** **critical values $-t_\alpha[60]$** of the t[60] distribution, where α is the chosen significance level for the one-tail t-test; they are taken from a published table of percentage points of the t distribution.

  $\alpha = 0.01$: $t_\alpha[60] = t_{0.01}[60] = -2.390$;
  $\alpha = 0.05$: $t_\alpha[60] = t_{0.05}[60] = -1.671$;
  $\alpha = 0.10$: $t_\alpha[60] = t_{0.10}[60] = -1.296$.

- The following commands use the **invttail(*df, p*)** statistical function to display the ***lower one-tail (left-tail)*** **critical values of the t[60] distribution**:

  display -1*invttail(60, 0.01)
  display -1*invttail(60, 0.05)
  display -1*invttail(60, 0.10)

```
. display -1*invttail(60, 0.01)
-2.3901195
. display -1*invttail(60, 0.05)
-1.6706489
. display -1*invttail(60, 0.10)
-1.2958211
```

- Now use the **ttail(*df, t_0*)** statistical function to display the ***left-tail*** **p-values** of the sample t-values $t_0 = -2.390$, -1.671, and -1.296, which you already know equal the corresponding values of α, namely 0.01, 0.05, and 0.10, respectively:

  display 1 - ttail(60, -2.390)
  display 1 - ttail(60, -1.671)
  display 1 - ttail(60, -1.296)

```
. display 1 - ttail(60, -2.390)
.01000296
. display 1 - ttail(60, -1.671)
.04996515
. display 1 - ttail(60, -1.296)
.09996938
```

❑ Computing critical values of F-distributions and p-values for F-statistics

Basic Syntax: The new *Stata 7* statistical functions for the F-distribution are **Ftail(*df*$_1$*, df*$_2$*, F*$_0$)** and **invFtail(*df*$_1$*, df*$_2$*, p*)**.

The new *Stata 7* function **Ftail(*df*$_1$*, df*$_2$*, F*$_0$)** is identical to the **fprob(*df*$_1$*, df*$_2$*, F*$_0$)** function of previous releases.

Similarly, the new *Stata 7* function **invFtail(*df*$_1$*, df*$_2$*, p*)** is identical to the **invfprob(*df*$_1$*, df*$_2$*, p*)** function of previous releases.

- **Ftail(*df*$_1$*, df*$_2$*, F*$_0$)** computes the ***right-tail (upper-tail) p-value of an F-statistic*** that has ***df*$_1$** *numerator* degrees of freedom, ***df*$_2$** *denominator* degrees of freedom, and calculated sample value ***F*$_0$**. It returns the probability that $F > F_0$, i.e., the value of $\Pr(F > F_0)$.

- **invFtail(*df*$_1$*, df*$_2$*, p*)** computes the ***right-tail critical value of an F-distribution*** with ***df*$_1$** *numerator* degrees of freedom, ***df*$_2$** *denominator* degrees of freedom, and ***probability level p***. If α denotes the chosen significance level for the F-test, then set $p = \alpha$.

- If **Ftail(*df*$_1$*, df*$_2$*, F*$_0$)** = ***p***, then **invFtail(*df*$_1$*, df*$_2$*, p*)** = ***F*$_0$**.

Usage: The statistical functions **Ftail(*df*$_1$*, df*$_2$*, F*$_0$)** and **invFtail(*df*$_1$*, df*$_2$*, p*)** must be used with *Stata 7* commands such as **display**, **generate**, **replace**, or **scalar**; they cannot be used by themselves.

Example:

- The following are the **critical values $F_{\alpha}[4, 60]$** of the F[4, 60] distribution, where α is the chosen significance level for the F-test; they are taken from a published table of upper percentage points of the F-distribution.

  $\alpha = 0.01$: $F_{\alpha}[4, 60] = F_{0.01}[4, 60] = 3.649$;
  $\alpha = 0.05$: $F_{\alpha}[4, 60] = F_{0.01}[4, 60] = 2.525$.

- The following commands use the **invFtail(*df_1*, *df_2*, *p*)** statistical function to display these **critical values of the F[4, 60] distribution** at the two chosen significance levels α, namely α = 0.01 and 0.05:

  display invFtail(4, 60, 0.01)
  display invFtail(4, 60, 0.05)

```
. display invFtail(4, 60, 0.01)
3.6490475
. display invFtail(4, 60, 0.05)
2.5252151
```

- Now use the **Ftail(*df_1*, *df_2*, *F_0*)** statistical function to display the ***right-tail* p-values** of the sample F-values F_0 = 3.649 and 2.525, which you already know equal the corresponding values of α, namely 0.01 and 0.05, respectively:

  display Ftail(4, 60, 3.649)
  display Ftail(4, 60, 2.525)

```
. display Ftail(4, 60, 3.649)
.01000067
. display Ftail(4, 60, 2.525)
.05001545
```