Using Stata for Two Sample Tests

All of the two sample problems we have discussed so far can be solved in Stata via either (a) statistical calculator functions, where you provide Stata with the necessary summary statistics for means, standard deviations, and sample sizes; these commands end with an i, where the i stands for "immediate" (but other commands also sometimes end with an i) (b) modules that directly analyze raw data; or (c) both. Some of these solutions require, or may be easier to solve, if you first add the Stataquest menus and commands; see

http://www.stata.com/support/faqs/res/quest7.html

The commands shown below can all be generated via Stata's pulldown menus if you prefer to use them.

A. 2 Sample Case I: σ_1 and σ_2 are known.

Problem. Indiana University (population 1) claims that it has a lower crime rate than Ohio State University (population 2). A random sample of crime rates for 12 different months is drawn for each school, yielding $\hat{\mu}_1 = 370$ and $\hat{\mu}_2 = 400$. It is known that $\sigma_1^2 = 400$ and $\sigma_2^2 = 800$. Test Indiana's claim at the .02 level of significance. Also, construct the 99% confidence interval.

Stata Solution. I don't know of a way to do this with raw data in Stata, but you can do it with summary statistics and the `ztest2i` command that is installed with Stataquest. The format is

```
ztest2i 12 370 20 12 400 28.28427125, level(99)
```

where the parameters are N1, Mean1, Known SD1, N2, Mean2, Known SD2, and desired CI level. Stata gives you

```
. ztest2i 12 370 20 12 400 28.28427125, level(99)

                                                x: Number of obs =        12
                                                y: Number of obs =        12

------------------------------------------------------------------------------
Variable |      Mean    Std. Err.        z     P>|z|       [99% Conf. Interval]
---------+--------------------------------------------------------------------
       x |       370    5.773503   64.0859    0.0000       355.1284    384.8716
       y |       400    8.164966   48.9898    0.0000       378.9684    421.0316
---------+--------------------------------------------------------------------
    diff |       -30          10         3    0.0027      -55.75829   -4.241707
------------------------------------------------------------------------------

                     Ho: mean(x) - mean(y) = diff = 0

      Ha: diff < 0            Ha: diff ~= 0              Ha: diff > 0
        z =  -3.0000             z =  -3.0000              z =  -3.0000
    P < z =   0.0013       P > |z| =   0.0027          P > z =   0.9987
```

The one-tailed probability of getting a difference this large just by chance is only .0013, so reject the null. We would also reject if the alternative was 2-tailed; the two-tailed probability is only .0027 and the 99% confidence interval for the difference does not include 0.

B. 2 Sample Case II: σ_1 and σ_2 are unknown but assumed to be equal.

1. A professor believes that women do better on her exams than men do. A sample of 8 women ($N_1 = 8$) and 10 men ($N_2 = 10$) yields $\hat{\mu}_1 = 7$, $\hat{\mu}_2 = 5.5$, $s_1^2 = 1$, $s_2^2 = 1.7$.

(a) Using $\alpha = .01$, test whether the female mean is greater than the male mean. Assume that $\sigma_1 = \sigma_2 = \sigma$.

(b) Compute the 99% confidence interval

Stata solution. The `ttesti` or `ttest` commands can be used. For `ttesti`, the format is

```
ttesti 8 7 1 10 5.5 1.303840481, level(99)
```

Parameters are N1 Mean1 SD1 N2 Mean2 SD2, CI Level. You get

```
. ttesti 8 7 1 10 5.5 1.303840481, level(99)

Two-sample t test with equal variances

------------------------------------------------------------------------------
         |     Obs        Mean    Std. Err.   Std. Dev.   [99% Conf. Interval]
---------+--------------------------------------------------------------------
       x |       8           7    .3535534           1    5.762746    8.237254
       y |      10         5.5    .4123106     1.30384    4.160058    6.839942
---------+--------------------------------------------------------------------
combined |      18    6.166667    .3248931    1.378405    5.225051    7.108282
---------+--------------------------------------------------------------------
    diff |                 1.5    .5599944               -.1356214    3.135621
------------------------------------------------------------------------------
Degrees of freedom: 16

                      Ho: mean(x) - mean(y) = diff = 0

     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =   2.6786               t =   2.6786               t =   2.6786
   P < t =   0.9918         P > |t| =   0.0165           P > t =   0.0082
```

The one-tailed probability of getting a difference this large is .0082; since that is less than .01, reject the null. If the alternative was two-tailed, you would not reject; .0165 is greater than .01. Also, 0 falls within the 99% confidence interval.

If you had the raw data, your data set would have 18 cases with 2 variables. The variable `gender` could be coded 1 if female, 2 if male. The variable `score` would equal the student's exam score. You use the `ttest` command with the `by` parameter to indicate that this is a separate samples t-test (default is to assume equal variances):

```
. ttest score, by(gender) level(99)

Two-sample t test with equal variances

------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [99% Conf. Interval]
---------+--------------------------------------------------------------------
  female |       8           7    .3535534           1    5.762746    8.237254
    male |      10         5.5    .4123106    1.303841    4.160058    6.839942
---------+--------------------------------------------------------------------
combined |      18    6.166667    .3248932    1.378405    5.225051    7.108282
---------+--------------------------------------------------------------------
    diff |                 1.5    .5599944               -.1356215    3.135621
------------------------------------------------------------------------------
Degrees of freedom: 16

                  Ho: mean(female) - mean(male) = diff = 0

     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =   2.6786               t =   2.6786              t =   2.6786
   P < t =   0.9918         P > |t| =   0.0165          P > t =   0.0082
```

C. 2 Sample Case III: σ_1 and σ_2 are not known and are not assumed to be equal.

Problem. Again work this problem: A professor believes that women do better on her exams than men do. A sample of 8 women ($N_1 = 8$) and 10 men ($N_2 = 10$) yields $\hat{\mu}_1 = 7$, $\hat{\mu}_2 = 5.5$, $s_1^2 = 1$, $s_2^2 = 1.7$. Using $\alpha = .01$, Test whether the female mean is greater than the male mean. DO NOT ASSUME $\sigma_1 = \sigma_2$.

Stata solution. Just add the `unequal` parameter to our earlier commands. For `ttesti`,

```
. ttesti 8 7 1 10 5.5 1.303840481, level(99) unequal

Two-sample t test with unequal variances

------------------------------------------------------------------------------
         |     Obs        Mean    Std. Err.   Std. Dev.   [99% Conf. Interval]
---------+--------------------------------------------------------------------
       x |       8           7    .3535534           1    5.762746    8.237254
       y |      10         5.5    .4123106     1.30384    4.160058    6.839942
---------+--------------------------------------------------------------------
combined |      18    6.166667    .3248931    1.378405    5.225051    7.108282
---------+--------------------------------------------------------------------
    diff |                 1.5     .543139                -.086552    3.086552
------------------------------------------------------------------------------
Satterthwaite's degrees of freedom:  15.9877

                      Ho: mean(x) - mean(y) = diff = 0

     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =   2.7617               t =   2.7617              t =   2.7617
   P < t =   0.9930         P > |t| =   0.0139          P > t =   0.0070
```

For the `ttest` command using raw data,

```
. ttest score, by(gender) level(99) unequal

Two-sample t test with unequal variances

------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [99% Conf. Interval]
---------+--------------------------------------------------------------------
  female |       8           7    .3535534           1    5.762746    8.237254
    male |      10         5.5    .4123106    1.303841    4.160058    6.839942
---------+--------------------------------------------------------------------
combined |      18    6.166667    .3248932    1.378405    5.225051    7.108282
---------+--------------------------------------------------------------------
    diff |                 1.5     .543139               -.0865521    3.086552
------------------------------------------------------------------------------
Satterthwaite's degrees of freedom:  15.9877

                  Ho: mean(female) - mean(male) = diff = 0

     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =   2.7617               t =   2.7617               t =   2.7617
   P < t =   0.9930          P > |t| =   0.0139          P > t =   0.0070
```

Incidentally, if, for some reason, you've always been a big fan of Welch's degrees of freedom rather than Satterthwaite's, just add the `welch` parameter to either version of the t-test command, e.g.

```
. ttest score, by(gender) level(99) unequal welch

Two-sample t test with unequal variances

------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [99% Conf. Interval]
---------+--------------------------------------------------------------------
  female |       8           7    .3535534           1    5.762746    8.237254
    male |      10         5.5    .4123106    1.303841    4.160058    6.839942
---------+--------------------------------------------------------------------
combined |      18    6.166667    .3248932    1.378405    5.225051    7.108282
---------+--------------------------------------------------------------------
    diff |                 1.5     .543139               -.0639565    3.063957
------------------------------------------------------------------------------
Welch's degrees of freedom:  17.9444

                  Ho: mean(female) - mean(male) = diff = 0

     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =   2.7617               t =   2.7617               t =   2.7617
   P < t =   0.9936          P > |t| =   0.0129          P > t =   0.0064
```

D. 2 Sample Case IV: Matched Pairs, σ unknown.

A researcher constructed a scale to measure influence on family decision-making, and collected the following data from 8 pairs of husbands and wives:

Pair #	H score	W score
1	26	30
2	28	29
3	28	28
4	29	27
5	30	26
6	31	25
7	34	24
8	37	23

(a) Test, at the .05 level, whether there is any significant difference between the average scores of husbands and wives.
(b) Construct the 95% c.i. for the average difference between the husband's and wife's score.

Stata Solution. Stata does not have a calculator function for matched pairs that I know of. However, remember that, if you have the mean and sample variance of D, you could solve such a problem the same way you would a Simple Sample Test, Case 3, Sigma unknown. You could then use the procedures described in the Single sample tests handout.

Analyzing raw data – the data set has 8 cases with two variables for each case: `hscore` (husband's score) and `wscore` (wife's score). Use the `ttest` command with the following format:

```
. ttest hscore = wscore, level(95)

Paired t test

------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  hscore |       8      30.375    1.266851    3.583195    27.37937    33.37063
  wscore |       8        26.5    .8660254     2.44949    24.45218    28.54782
---------+--------------------------------------------------------------------
    diff |       8       3.875    2.108126    5.962682   -1.109927    8.859927
------------------------------------------------------------------------------

                 Ho: mean(hscore - wscore) = mean(diff) = 0

  Ha: mean(diff) < 0          Ha: mean(diff) != 0         Ha: mean(diff) > 0
       t =   1.8381                t =   1.8381               t =   1.8381
   P < t =   0.9457          P > |t| =   0.1086           P > t =   0.0543
```

Both the t-value and the confidence interval indicate you should not reject the null; the means of the husbands and wives do not significantly differ.

Minor Sidelight – Easily switching from Case IV to Case II or III: If you have set the data up for Case IV, Matched Pairs – but for some reason would like to treat the problem as though it fell under Case II or III – Stata makes it easy to do so. All you have to do is add the `unpaired` option to the `ttest` command, e.g., for Case II,

```
. ttest  hscore = wscore, unpaired level(95)

Two-sample t test with equal variances

------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  hscore |       8      30.375    1.266851    3.583195    27.37937    33.37063
  wscore |       8        26.5    .8660254     2.44949    24.45218    28.54782
---------+--------------------------------------------------------------------
combined |      16     28.4375    .8942816    3.577126    26.53138    30.34362
---------+--------------------------------------------------------------------
    diff |               3.875    1.534572                .5836708    7.166329
------------------------------------------------------------------------------
Degrees of freedom: 14

                 Ho: mean(hscore) - mean(wscore) = diff = 0

     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =   2.5251               t =   2.5251               t =   2.5251
   P < t =   0.9879         P > |t| =   0.0243           P > t =   0.0121
```

For Case III,

```
. ttest  hscore = wscore, unpaired unequal level(95)

Two-sample t test with unequal variances

------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
  hscore |       8      30.375    1.266851    3.583195    27.37937    33.37063
  wscore |       8        26.5    .8660254     2.44949    24.45218    28.54782
---------+--------------------------------------------------------------------
combined |      16     28.4375    .8942816    3.577126    26.53138    30.34362
---------+--------------------------------------------------------------------
    diff |               3.875    1.534572                .5425064    7.207494
------------------------------------------------------------------------------
Satterthwaite's degrees of freedom:  12.3698

                 Ho: mean(hscore) - mean(wscore) = diff = 0

     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =   2.5251               t =   2.5251               t =   2.5251
   P < t =   0.9869         P > |t| =   0.0261           P > t =   0.0131
```

E. 2 Sample Case V: Difference between two proportions.

1. Two groups, A and B, each consist of 100 randomly assigned people who have a disease. One serum is given to Group A and a different serum is given to Group B; otherwise, the two groups are treated identically. It is found that in groups A and B, 75 and 65 people, respectively, recover from the disease.

(a) Test the hypothesis that the serums differ in their effectiveness using α = .05.

(b) Compute the approximate 95% c.i. for $\hat{p}_1 - \hat{p}_2$.

Stata solution. Use the `prtesti` or `prtest` command. Using `prtesti`,

`. prtesti 100 .75 100 .65, level(95)` (i.e. N1 p1 N2 p2, desired CI level)

```
Two-sample test of proportion                     x: Number of obs =      100
                                                  y: Number of obs =      100

------------------------------------------------------------------------------
    Variable |       Mean   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           x |        .75   .0433013                      .6651311    .8348689
           y |        .65    .047697                      .5565157    .7434843
-------------+----------------------------------------------------------------
        diff |         .1   .0644205                     -.0262618    .2262618
             |  under Ho:   .0648074     1.54   0.123
------------------------------------------------------------------------------

               Ho: proportion(x) - proportion(y) = diff = 0

       Ha: diff < 0            Ha: diff != 0            Ha: diff > 0
        z =  1.543               z =  1.543              z =  1.543
    P < z =  0.9386        P > |z| =  0.1228         P > z =  0.0614
```

For analyzing raw data – you have 200 cases with 2 variables. `recover` is coded 1 if the patient recovered, 0 otherwise. `group` is coded 1 if in group A, 2 if in group B. Use the `prtest` command with the `by` parameter:

`. prtest recover, by(group) level(95)`

```
Two-sample test of proportion               Group A: Number of obs =      100
                                            Group B: Number of obs =      100

------------------------------------------------------------------------------
    Variable |       Mean   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     Group A |        .75   .0433013                      .6651311    .8348689
     Group B |        .65    .047697                      .5565157    .7434843
-------------+----------------------------------------------------------------
        diff |         .1   .0644205                     -.0262618    .2262618
             |  under Ho:   .0648074     1.54   0.123
------------------------------------------------------------------------------

         Ho: proportion(Group A) - proportion(Group B) = diff = 0

       Ha: diff < 0            Ha: diff != 0            Ha: diff > 0
        z =  1.543               z =  1.543              z =  1.543
    P < z =  0.9386        P > |z| =  0.1228         P > z =  0.0614
```

Both the z value and the confidence interval indicate you should not reject the null; the two serums do not significantly differ in their effectiveness.