```
. /*****************************************************
> Linear Regression Models for Panel Data using STATA
> Data: R&D Expenditure of IT firms (OECD 2002)
>       Airline cost data (Greene 2003)
>
> Created on June 21, 2004
> Last Modified on November 23, 2005
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> *****************************************************/

.
. /*************************************************/
. // Cost of U.S. Airlines (Greene 2003)
. /*************************************************/
.
. infile int airline int year cost0 output0 fuel0 load using airline.txt, clear
(90 observations read)

.
. // log transformation
. gen cost=ln(cost0)

. gen output=ln(output0)

. gen fuel=ln(fuel0)

.
.
. // create dummy varaibles
. forvalues i= 1(1)6 { // create dummies for groups
  2.    gen byte g`i'=0
  3.    replace g`i'=1 if airline==`i'
  4.    tab g`i' airline
  5. }
(15 real changes made)

           |                                 airline
        g1 |         1          2          3          4          5          6 |
Total
-----------+---------------------------------------------------------------------
+----------
         0 |         0         15         15         15         15         15 |
75
         1 |        15          0          0          0          0          0 |
15
-----------+---------------------------------------------------------------------
+----------
     Total |        15         15         15         15         15         15 |
90

(15 real changes made)

           |                                 airline
        g2 |         1          2          3          4          5          6 |
Total
-----------+---------------------------------------------------------------------
+----------
         0 |        15          0         15         15         15         15 |
75
         1 |         0         15          0          0          0          0 |
15
-----------+---------------------------------------------------------------------
+----------
```

```
     Total |        15         15         15         15         15         15 |
90

(15 real changes made)

           |                              airline
        g3 |         1          2          3          4          5          6 |
Total
-----------+------------------------------------------------------------------
+----------
         0 |        15         15          0         15         15         15 |
75
         1 |         0          0         15          0          0          0 |
15
-----------+------------------------------------------------------------------
+----------
     Total |        15         15         15         15         15         15 |
90

(15 real changes made)

           |                              airline
        g4 |         1          2          3          4          5          6 |
Total
-----------+------------------------------------------------------------------
+----------
         0 |        15         15         15          0         15         15 |
75
         1 |         0          0          0         15          0          0 |
15
-----------+------------------------------------------------------------------
+----------
     Total |        15         15         15         15         15         15 |
90

(15 real changes made)

           |                              airline
        g5 |         1          2          3          4          5          6 |
Total
-----------+------------------------------------------------------------------
+----------
         0 |        15         15         15         15          0         15 |
75
         1 |         0          0          0          0         15          0 |
15
-----------+------------------------------------------------------------------
+----------
     Total |        15         15         15         15         15         15 |
90

(15 real changes made)

           |                              airline
        g6 |         1          2          3          4          5          6 |
Total
-----------+------------------------------------------------------------------
+----------
         0 |        15         15         15         15         15          0 |
75
         1 |         0          0          0          0          0         15 |
15
-----------+------------------------------------------------------------------
+----------
     Total |        15         15         15         15         15         15 |
90
```

```
.
. forvalues j= 1(1)15 { // create dummies for time
  2.    gen byte t`j'=0
  3.    replace t`j'=1 if year==`j'
  4.    tab t`j' year
  5. }
(6 real changes made)

           |                                                                                                year
        t1 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------------------------------------
---------------------------+----------
         0 |         0          6          6          6          6          6
6          6          6          6 |        84
         1 |         6          0          0          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                           year
        t1 |        11         12         13         14         15 |     Total
-----------+--------------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+--------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                                                                year
        t2 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          0          6          6          6          6
6          6          6          6 |        84
         1 |         0          6          0          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                           year
        t2 |        11         12         13         14         15 |     Total
-----------+--------------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+--------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                                                                year
        t3 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
```

```
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          0          6          6          6
6          6          6          6 |        84
         1 |         0          0          6          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                          year
        t3 |        11         12         13         14         15 |     Total
-----------+-------------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+-------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
        t4 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          0          6          6
6          6          6          6 |        84
         1 |         0          0          0          6          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                          year
        t4 |        11         12         13         14         15 |     Total
-----------+-------------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+-------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
        t5 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          0          6
6          6          6          6 |        84
         1 |         0          0          0          0          6          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90
```

```
           |                          year
        t5 |        11         12         13         14         15 |     Total
-----------+-----------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+-----------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
        t6 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          6          0
6          6          6          6 |        84
         1 |         0          0          0          0          0          6
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                          year
        t6 |        11         12         13         14         15 |     Total
-----------+-----------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+-----------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
        t7 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          6          6
0          6          6          6 |        84
         1 |         0          0          0          0          0          0
6          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                          year
        t7 |        11         12         13         14         15 |     Total
-----------+-----------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+-----------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
        t8 |         1          2          3          4          5          6
7          8          9         10 |     Total
```

```
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          6          6
6          0          6          6 |        84
         1 |         0          0          0          0          0          0
0          6          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


            |                         year
         t8 |        11         12         13         14         15 |     Total
------------+-----------------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
------------+-----------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

            |                                                    year
         t9 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          6          6
6          6          0          6 |        84
         1 |         0          0          0          0          0          0
0          0          6          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


            |                         year
         t9 |        11         12         13         14         15 |     Total
------------+-----------------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
------------+-----------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

            |                                                    year
        t10 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          6          6
6          6          6          0 |        84
         1 |         0          0          0          0          0          0
0          0          0          6 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90
```

```
           |                          year
       t10 |        11         12         13         14         15 |     Total
-----------+-----------------------------------------------------+----------
         0 |         6          6          6          6          6 |        84
         1 |         0          0          0          0          0 |         6
-----------+-----------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
       t11 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          6          6
6          6          6          6 |        84
         1 |         0          0          0          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                          year
       t11 |        11         12         13         14         15 |     Total
-----------+-----------------------------------------------------+----------
         0 |         0          6          6          6          6 |        84
         1 |         6          0          0          0          0 |         6
-----------+-----------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
       t12 |         1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |         6          6          6          6          6          6
6          6          6          6 |        84
         1 |         0          0          0          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                          year
       t12 |        11         12         13         14         15 |     Total
-----------+-----------------------------------------------------+----------
         0 |         6          0          6          6          6 |        84
         1 |         0          6          0          0          0 |         6
-----------+-----------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90

(6 real changes made)

           |                                                    year
       t13 |         1          2          3          4          5          6
```

```
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |          6          6          6          6          6          6
6          6          6          6 |        84
         1 |          0          0          0          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |          6          6          6          6          6          6
6          6          6          6 |        90


            |                           year
       t13 |         11         12         13         14         15 |     Total
-----------+-------------------------------------------------------+----------
         0 |          6          6          0          6          6 |        84
         1 |          0          0          6          0          0 |         6
-----------+-------------------------------------------------------+----------
     Total |          6          6          6          6          6 |        90

(6 real changes made)

            |                                                     year
       t14 |          1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |          6          6          6          6          6          6
6          6          6          6 |        84
         1 |          0          0          0          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |          6          6          6          6          6          6
6          6          6          6 |        90


            |                           year
       t14 |         11         12         13         14         15 |     Total
-----------+-------------------------------------------------------+----------
         0 |          6          6          6          0          6 |        84
         1 |          0          0          0          6          0 |         6
-----------+-------------------------------------------------------+----------
     Total |          6          6          6          6          6 |        90

(6 real changes made)

            |                                                     year
       t15 |          1          2          3          4          5          6
7          8          9         10 |     Total
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
         0 |          6          6          6          6          6          6
6          6          6          6 |        84
         1 |          0          0          0          0          0          0
0          0          0          0 |         6
-----------
+-------------------------------------------------------------------------------
---------------------------+----------
     Total |          6          6          6          6          6          6
6          6          6          6 |        90
```

```
           |                          year
       t15 |        11         12         13         14         15 |     Total
-----------+---------------------------------------------------------+----------
         0 |         6          6          6          6          0 |        84
         1 |         0          0          0          0          6 |         6
-----------+---------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90


.
. save "airline.dta", replace
file airline.dta saved

.
.
.
. /***********************************************/
. // Pooled OLS: No group and time effect
.
. regress cost output fuel load // pooled regression

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  3,    86) = 2419.34
       Model |  112.705452     3  37.5684839           Prob > F      =  0.0000
    Residual |  1.33544153    86   .01552839           R-squared     =  0.9883
-------------+------------------------------           Adj R-squared =  0.9879
       Total |  114.040893    89  1.28135835           Root MSE      =  .12461

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8827385   .0132545    66.60   0.000     .8563895    .9090876
        fuel |    .453977   .0203042    22.36   0.000     .4136136    .4943404
        load |   -1.62751    .345302    -4.71   0.000    -2.313948   -.9410727
       _cons |   9.516923   .2292445    41.51   0.000       9.0612    9.972645
------------------------------------------------------------------------------

. predict resid, resid

.
.
. /***********************************************/
. // One way fixed group effect model
.
. // LSDV1: Without one dummy variable
. regress cost g1-g5 output fuel load // LSDV1

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  8,    81) = 3935.79
       Model |   113.74827     8  14.2185338           Prob > F      =  0.0000
    Residual |  .292622872    81  .003612628           R-squared     =  0.9974
-------------+------------------------------           Adj R-squared =  0.9972
       Total |  114.040893    89  1.28135835           Root MSE      =  .06011

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |  -.0870617   .0841995    -1.03   0.304    -.2545924     .080469
          g2 |  -.1282976   .0757281    -1.69   0.094    -.2789728    .0223776
          g3 |  -.2959828   .0500231    -5.92   0.000     -.395513   -.1964526
          g4 |    .097494   .0330093     2.95   0.004     .0318159    .1631721
          g5 |   -.063007   .0238919    -2.64   0.010    -.1105443   -.0154697
      output |   .9192846   .0298901    30.76   0.000     .8598126    .9787565
        fuel |   .4174918   .0151991    27.47   0.000     .3872503    .4477333
        load |  -1.070396     .20169    -5.31   0.000    -1.471696   -.6690963
```

```
       _cons |   9.793004   .2636622    37.14   0.000     9.268399    10.31761
------------------------------------------------------------------------------

. regress cost g1-g2 g4-g6 output fuel load // LSDV1 dropping g3

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  8,    81) = 3935.79
       Model |   113.74827     8  14.2185338           Prob > F      =  0.0000
    Residual |  .292622872    81  .003612628           R-squared     =  0.9974
-------------+------------------------------           Adj R-squared =  0.9972
       Total |  114.040893    89  1.28135835           Root MSE      =  .06011

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |   .2089211   .0427986     4.88   0.000     .1237652    .2940769
          g2 |   .1676852   .0370516     4.53   0.000     .0939642    .2414062
          g4 |   .3934768   .0299572    13.13   0.000     .3338713    .4530823
          g5 |   .2329758   .0457045     5.10   0.000     .1420383    .3239133
          g6 |   .2959828   .0500231     5.92   0.000     .1964526     .395513
      output |   .9192846   .0298901    30.76   0.000     .8598126    .9787565
        fuel |   .4174918   .0151991    27.47   0.000     .3872503    .4477333
        load |  -1.070396     .20169    -5.31   0.000    -1.471696   -.6690963
       _cons |   9.497021   .2249584    42.22   0.000     9.049424    9.944618
------------------------------------------------------------------------------

.
. quietly regress cost g1-g5 output fuel load

. test g1 g2 g3 g4 g5 // test group effects

 ( 1)  g1 = 0
 ( 2)  g2 = 0
 ( 3)  g3 = 0
 ( 4)  g4 = 0
 ( 5)  g5 = 0

       F(  5,    81) =   57.73
            Prob > F =    0.0000

.
.
. // LSDV2: Without an intercept
. regress cost g1-g6 output fuel load, noc // LSDV2

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  9,    81) =       .
       Model |  16191.3043     9  1799.03381           Prob > F      =  0.0000
    Residual |  .292622872    81  .003612628           R-squared     =  1.0000
-------------+------------------------------           Adj R-squared =  1.0000
       Total |  16191.5969    90  179.906633           Root MSE      =  .06011

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |   9.705942    .193124    50.26   0.000     9.321686     10.0902
          g2 |   9.664706    .198982    48.57   0.000     9.268794    10.06062
          g3 |   9.497021   .2249584    42.22   0.000     9.049424    9.944618
          g4 |   9.890498   .2417635    40.91   0.000     9.409464    10.37153
          g5 |   9.729997   .2609421    37.29   0.000     9.210804    10.24919
          g6 |   9.793004   .2636622    37.14   0.000     9.268399    10.31761
      output |   .9192846   .0298901    30.76   0.000     .8598126    .9787565
        fuel |   .4174918   .0151991    27.47   0.000     .3872503    .4477333
        load |  -1.070396     .20169    -5.31   0.000    -1.471696   -.6690963
------------------------------------------------------------------------------

.
```

```
.
. // LSDV3: With a restriciton
. constraint define 2 g1 + g2 + g3 + g4 + g5 + g6 = 0

. cnsreg cost g1-g6 output fuel load, constraint(2)

Constrained linear regression                   Number of obs =      90
                                                F(  8,    81) = 3935.79
                                                Prob > F      =  0.0000
                                                Root MSE      =  .06011
 ( 1)  g1 + g2 + g3 + g4 + g5 + g6 = 0
------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |  -.0075859   .0456178    -0.17   0.868    -.0983509    .0831792
          g2 |  -.0488218   .0379787    -1.29   0.202    -.1243875    .0267439
          g3 |  -.2165069   .0160624   -13.48   0.000    -.2484661   -.1845478
          g4 |   .1769698   .0194247     9.11   0.000     .1383208    .2156189
          g5 |   .0164689   .0366904     0.45   0.655    -.0565335    .0894712
          g6 |   .0794759   .0405008     1.96   0.053     -.001108    .1600597
      output |   .9192846   .0298901    30.76   0.000     .8598126    .9787565
        fuel |   .4174918   .0151991    27.47   0.000     .3872503    .4477333
        load |  -1.070396     .20169    -5.31   0.000    -1.471696   -.6690963
       _cons |   9.713528    .229641    42.30   0.000     9.256614    10.17044
------------------------------------------------------------------------------

.
.
.
. /***********************************************/
. // within effect model (group effect)
.
. egen gm_cost=mean(cost), by(airline) // compute group means

. egen gm_output=mean(output), by(airline)

. egen gm_fuel=mean(fuel), by(airline)

. egen gm_load=mean(load), by(airline)

.
. gen gw_cost = cost - gm_cost // transform variables

. gen gw_output = output - gm_output

. gen gw_fuel = fuel - gm_fuel

. gen gw_load = load - gm_load

.
.
. regress gw_cost gw_output gw_fuel gw_load, noc  // within effect using .regress

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  3,    87) = 3871.82
       Model |  39.0683861     3  13.0227954            Prob > F      =  0.0000
    Residual |  .292622861    87  .003363481            R-squared     =  0.9926
-------------+------------------------------           Adj R-squared =  0.9923
       Total |   39.361009    90  .437344544            Root MSE      =    .058

------------------------------------------------------------------------------
     gw_cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   gw_output |   .9192846    .028841    31.87   0.000       .86196    .9766092
     gw_fuel |   .4174918   .0146657    28.47   0.000     .3883422    .4466414
     gw_load |  -1.070396   .1946109    -5.50   0.000    -1.457206   -.6835858
------------------------------------------------------------------------------
```

```
. predict ge, resid

.
.
. tsset airline year // specify group and time
       panel variable:  airline, 1 to 6
        time variable:  year, 1 to 15

. xtreg cost output fuel load, fe i(airline) // within effect using .xtreg

Fixed-effects (within) regression               Number of obs      =        90
Group variable (i): airline                     Number of groups   =         6

R-sq:  within  = 0.9926                         Obs per group: min =        15
       between = 0.9856                                        avg =      15.0
       overall = 0.9873                                        max =        15

                                                F(3,81)            =   3604.80
corr(u_i, Xb)  = -0.3475                        Prob > F           =    0.0000

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .9192846   .0298901    30.76   0.000     .8598126    .9787565
        fuel |   .4174918   .0151991    27.47   0.000     .3872503    .4477333
        load |  -1.070396     .20169    -5.31   0.000    -1.471696   -.6690963
       _cons |   9.713528    .229641    42.30   0.000     9.256614    10.17044
-------------+----------------------------------------------------------------
     sigma_u |   .1320775
     sigma_e |  .06010514
         rho |  .82843653   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(5, 81) =    57.73              Prob > F = 0.0000

.
. save "airline.dta", replace
file airline.dta saved

.
.
.
. /***********************************************/
. // Between effect model
.
. xtreg cost output fuel load, be i(airline) // between effect using .xtreg

Between regression (regression on group means)  Number of obs      =        90
Group variable (i): airline                     Number of groups   =         6

R-sq:  within  = 0.8808                         Obs per group: min =        15
       between = 0.9936                                        avg =      15.0
       overall = 0.1371                                        max =        15

                                                F(3,2)             =    104.12
sd(u_i + avg(e_i.))=  .1258491                  Prob > F           =    0.0095

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .7824552   .1087663     7.19   0.019     .3144715    1.250439
        fuel |  -5.523978   4.478802    -1.23   0.343    -24.79471    13.74675
        load |  -1.751016    2.74319    -0.64   0.589    -13.55401    10.05198
       _cons |   85.80901   56.48302     1.52   0.268    -157.2178    328.8358
------------------------------------------------------------------------------

.
```

```
.
. // compute group means
. collapse (mean) gm_cost=cost (mean) gm_output=output (mean) gm_fuel=fuel (mean)
gm_load=load, by(airline)

. list, sep(10) noobs // list time means of variables

  +-------------------------------------------------------+
  | airline    gm_cost   gm_output    gm_fuel    gm_load |
  |-------------------------------------------------------|
  |       1   14.67563    .3192696    12.7318   .5971917 |
  |       2   14.37247    -.033027   12.75171   .5470946 |
  |       3   13.37231   -.9122626   12.78972   .5845358 |
  |       4    13.1358   -1.635174   12.77803   .5476773 |
  |       5   12.36304   -2.285681    12.7921   .5664859 |
  |       6   12.27441    -2.49898    12.7788   .5197756 |
  +-------------------------------------------------------+

.
. regress gm_cost gm_output gm_fuel gm_load // between effect using .regress

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =  104.12
       Model |  4.94698124     3  1.64899375           Prob > F      =  0.0095
    Residual |  .031675926     2  .015837963           R-squared     =  0.9936
-------------+------------------------------           Adj R-squared =  0.9841
       Total |  4.97865717     5  .995731433           Root MSE      =  .12585

------------------------------------------------------------------------------
     gm_cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   gm_output |   .7824568   .1087646     7.19   0.019     .3144803    1.250433
     gm_fuel |  -5.523904   4.478718    -1.23   0.343    -24.79427    13.74647
     gm_load |  -1.751072   2.743167    -0.64   0.589    -13.55397    10.05182
       _cons |    85.8081   56.48199     1.52   0.268    -157.2143    328.8305
------------------------------------------------------------------------------

.
.
.
. /***************************************************/
. // One way fixed time effect model
. /***************************************************/
. use "airline.dta", clear

.
. // LSDV1: Without one dummy variable
. regress cost t1-t14 output fuel load // LSDV1

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F( 17,    72) =  439.62
       Model |  112.952703    17  6.64427664           Prob > F      =  0.0000
    Residual |  1.08819022    72  .015113753           R-squared     =  0.9905
-------------+------------------------------           Adj R-squared =  0.9882
       Total |  114.040893    89  1.28135835           Root MSE      =  .12294

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          t1 |  -2.040961   .7346895    -2.78   0.007    -3.505538   -.5763841
          t2 |  -1.958727    .722751    -2.71   0.008    -3.399505    -.517949
          t3 |  -1.881035   .7203646    -2.61   0.011    -3.317055   -.4450141
          t4 |  -1.796007   .6988248    -2.57   0.012    -3.189089   -.4029254
          t5 |  -1.336934   .5060449    -2.64   0.010    -2.345716   -.3281515
          t6 |  -1.125145   .4086219    -2.75   0.007    -1.939718    -.310572
          t7 |  -1.033415   .3764164    -2.75   0.008    -1.783787   -.2830424
          t8 |  -.8827374   .3260131    -2.71   0.008    -1.532633   -.2328421
```

```
          t9 |  -.7071945   .2947012    -2.40   0.019    -1.294671   -.1197184
         t10 |   -.422963   .1667892    -2.54   0.013    -.7554513   -.0904747
         t11 |  -.0714383   .0717639    -1.00   0.323    -.2144969    .0716203
         t12 |   .1145714    .098412     1.16   0.248    -.0816094    .3107522
         t13 |   .0797895    .084417     0.95   0.348    -.0884928    .2480717
         t14 |   .0154627   .0726397     0.21   0.832     -.129342    .1602674
      output |   .8677268   .0154082    56.32   0.000     .8370111    .8984424
        fuel |  -.4844835   .3641085    -1.33   0.188    -1.210321    .2413535
        load |  -1.954404   .4423777    -4.42   0.000    -2.836268    -1.07254
       _cons |   22.53677   4.940532     4.56   0.000     12.68799    32.38554
------------------------------------------------------------------------------

. predict te, resid

. test t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11 t12 t13 t14

 ( 1)  t1 = 0
 ( 2)  t2 = 0
 ( 3)  t3 = 0
 ( 4)  t4 = 0
 ( 5)  t5 = 0
 ( 6)  t6 = 0
 ( 7)  t7 = 0
 ( 8)  t8 = 0
 ( 9)  t9 = 0
 (10)  t10 = 0
 (11)  t11 = 0
 (12)  t12 = 0
 (13)  t13 = 0
 (14)  t14 = 0

       F( 14,    72) =    1.17
            Prob > F =    0.3178

.
.
. // 'LSDV2: Without an intercept';
. regress cost t1-t15 output fuel load, noc // LSDV2

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F( 18,    72) =59513.52
       Model |  16190.5087    18  899.472708           Prob > F      =  0.0000
    Residual |  1.08819022    72  .015113753           R-squared     =  0.9999
-------------+------------------------------           Adj R-squared =  0.9999
       Total |  16191.5969    90  179.906633           Root MSE      =  .12294

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          t1 |    20.4958   4.209528     4.87   0.000     12.10426    28.88735
          t2 |   20.57804   4.221526     4.87   0.000     12.16258     28.9935
          t3 |   20.65573   4.224177     4.89   0.000     12.23499    29.07647
          t4 |   20.74076    4.24575     4.89   0.000     12.27701    29.20451
          t5 |   21.19983   4.440331     4.77   0.000     12.34819    30.05147
          t6 |   21.41162   4.538621     4.72   0.000     12.36404     30.4592
          t7 |   21.50335   4.571397     4.70   0.000     12.39044    30.61626
          t8 |   21.65403   4.622886     4.68   0.000     12.43847    30.86958
          t9 |   21.82957   4.656906     4.69   0.000      12.5462    31.11294
         t10 |    22.1138   4.792648     4.61   0.000     12.55983    31.66777
         t11 |   22.46533   4.949909     4.54   0.000     12.59786    32.33279
         t12 |   22.65134   5.008592     4.52   0.000     12.66689    32.63578
         t13 |   22.61656   4.986139     4.54   0.000     12.67687    32.55624
         t14 |   22.55223   4.955942     4.55   0.000     12.67274    32.43172
         t15 |   22.53677   4.940532     4.56   0.000     12.68799    32.38554
      output |   .8677268   .0154082    56.32   0.000     .8370111    .8984424
        fuel |  -.4844835   .3641085    -1.33   0.188    -1.210321    .2413535
        load |  -1.954404   .4423777    -4.42   0.000    -2.836268    -1.07254
```

```
------------------------------------------------------------------------------

.
.
. // 'LSDV3: With a restriciton';
. constraint define 3 t1+t2+t3+t4+t5+t6+t7+t8+t9+t10+t11+t12+t13+t14+t15=0

. cnsreg cost t1-t15 output fuel load, constraint(3)

Constrained linear regression                   Number of obs =      90
                                                F( 17,    72) =  439.62
                                                Prob > F      =  0.0000
                                                Root MSE      =  .12294
 ( 1)  t1 + t2 + t3 + t4 + t5 + t6 + t7 + t8 + t9 + t10 + t11 + t12 + t13 + t14 +
t15 = 0
------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          t1 |  -1.171179   .4178338    -2.80   0.007    -2.004115   -.3382422
          t2 |  -1.088945   .4058579    -2.68   0.009    -1.898008   -.2798816
          t3 |  -1.011252   .4032308    -2.51   0.014    -1.815078   -.2074266
          t4 |  -.9262249   .3817675    -2.43   0.018    -1.687265   -.1651852
          t5 |  -.4671515   .1907596    -2.45   0.017    -.8474239   -.0868791
          t6 |  -.2553627   .0985615    -2.59   0.012    -.4518415   -.0588839
          t7 |  -.1636326   .0718969    -2.28   0.026    -.3069564   -.0203088
          t8 |  -.0129552   .0486249    -0.27   0.791    -.1098872    .0839768
          t9 |   .1625876   .0627099     2.59   0.012     .0375776    .2875976
         t10 |   .4468191    .175994     2.54   0.013     .0959814    .7976568
         t11 |   .7983439   .3294027     2.42   0.018     .1416916    1.454996
         t12 |   .9843536   .3875583     2.54   0.013     .2117702    1.756937
         t13 |   .9495716   .3653675     2.60   0.011     .2212248    1.677918
         t14 |   .8852448   .3354912     2.64   0.010     .2164554    1.554034
         t15 |   .8697821   .3202933     2.72   0.008     .2312891    1.508275
      output |   .8677268   .0154082    56.32   0.000     .8370111    .8984424
        fuel |  -.4844835   .3641085    -1.33   0.188    -1.210321    .2413535
        load |  -1.954404   .4423777    -4.42   0.000    -2.836268    -1.07254
       _cons |   21.66698   4.624053     4.69   0.000      12.4491    30.88486
------------------------------------------------------------------------------

.
. save "airline.dta", replace
file airline.dta saved

.
.
.
. /***************************************************/
. // within effect model
.
. egen tm_cost = mean(cost), by(year) // compute time means

. egen tm_output = mean(output), by(year)

. egen tm_fuel = mean(fuel), by(year)

. egen tm_load = mean(load), by(year)

.
. gen tw_cost = cost - tm_cost // transform variables

. gen tw_output = output - tm_output

. gen tw_fuel = fuel - tm_fuel

. gen tw_load = load - tm_load

.
```

```
. save "airline.dta", replace
file airline.dta saved

.
.
. regress tw_cost tw_output tw_fuel tw_load, noc // within effect using .regress

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  3,    87) = 2015.95
       Model |  75.6459391     3   25.215313           Prob > F      =  0.0000
    Residual |  1.08819023    87  .012507934           R-squared     =  0.9858
-------------+------------------------------           Adj R-squared =  0.9853
       Total |  76.7341294    90  .852601437           Root MSE      =  .11184

------------------------------------------------------------------------------
     tw_cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   tw_output |   .8677268   .0140171    61.90   0.000     .8398663    .8955873
     tw_fuel |  -.4844836   .3312359    -1.46   0.147    -1.142851    .1738836
     tw_load |  -1.954404   .4024388    -4.86   0.000    -2.754295   -1.154514
------------------------------------------------------------------------------

.
.
. tsset year airline // to specify group and time
       panel variable:  year, 1 to 15
        time variable:  airline, 1 to 6

. xtreg cost output fuel load, fe i(year) // within effect using .xtreg

Fixed-effects (within) regression               Number of obs      =        90
Group variable (i): year                        Number of groups   =        15

R-sq:  within  = 0.9858                         Obs per group: min =         6
       between = 0.4812                                        avg =       6.0
       overall = 0.5265                                        max =         6

                                                F(3,72)            =   1668.37
corr(u_i, Xb)  = -0.1503                        Prob > F           =    0.0000

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8677268   .0154082    56.32   0.000     .8370111    .8984424
        fuel |  -.4844835   .3641085    -1.33   0.188    -1.210321    .2413535
        load |  -1.954404   .4423777    -4.42   0.000    -2.836268    -1.07254
       _cons |   21.66698   4.624053     4.69   0.000      12.4491    30.88486
-------------+----------------------------------------------------------------
     sigma_u |   .8027907
     sigma_e |  .12293801
         rho |  .97708602   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(14, 72) =     1.17                 Prob > F = 0.3178

.
.
.
. /***********************************************/
. // Between effect model
.
. xtreg cost output fuel load, be i(year) // between effect using .xtreg

Between regression (regression on group means)  Number of obs      =        90
Group variable (i): year                        Number of groups   =        15

R-sq:  within  = 0.9840                         Obs per group: min =         6
       between = 0.9991                                        avg =       6.0
```

```
       overall = 0.9749                                        max =         6

                                               F(3,11)           =   4074.35
sd(u_i + avg(e_i.))=  .0225441                 Prob > F          =    0.0000

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   1.133335   .0512897    22.10   0.000     1.020447    1.246223
        fuel |   .3342494   .0228284    14.64   0.000     .2840044    .3844943
        load |   -1.35073   .2478257    -5.45   0.000    -1.896191   -.8052695
       _cons |   11.18504   .3660008    30.56   0.000     10.37948     11.9906
------------------------------------------------------------------------------

.
.
. collapse (mean) tm_cost=cost (mean) tm_output=output (mean) tm_fuel=fuel (mean)
tm_load=load, by(year)

. list, sep(10) noobs // list time means of variables

  +-------------------------------------------------+
  | year    tm_cost   tm_output    tm_fuel    tm_load |
  |-------------------------------------------------|
  |    1   12.36897   -1.790283   11.63606   .4788587 |
  |    2   12.45963   -1.744389   11.66868   .4868322 |
  |    3   12.60706   -1.577767   11.67494     .52358 |
  |    4   12.77912   -1.443695   11.73193   .5244486 |
  |    5   12.94143   -1.398122   12.26843   .5635266 |
  |    6    13.0452   -1.393002   12.53826   .5541809 |
  |    7   13.15965   -1.302416   12.62714   .5607425 |
  |    8   13.29884   -1.222963   12.76768   .5670587 |
  |    9    13.4651   -1.067003   12.86104   .6179098 |
  |   10   13.70187   -.9023156   13.23183   .6233943 |
  |-------------------------------------------------|
  |   11   13.91324   -.9205539   13.66246   .5802577 |
  |   12   14.05984   -.8641667   13.82315   .5856243 |
  |   13   14.12841   -.7923916   13.75979   .5803183 |
  |   14   14.23517   -.6428015   13.67403   .5804528 |
  |   15   14.32062   -.5527684   13.62997   .5797168 |
  +-------------------------------------------------+

.
. regress tm_cost tm_output tm_fuel tm_load // between effect using .regress

      Source |       SS       df       MS              Number of obs =      15
-------------+------------------------------           F(  3,    11) = 4074.33
       Model |  6.21220479     3  2.07073493           Prob > F      =  0.0000
    Residual |  .005590631    11  .000508239           R-squared     =  0.9991
-------------+------------------------------           Adj R-squared =  0.9989
       Total |  6.21779542    14  .444128244           Root MSE      =  .02254

------------------------------------------------------------------------------
     tm_cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   tm_output |   1.133337   .0512898    22.10   0.000     1.020449    1.246225
     tm_fuel |   .3342486   .0228284    14.64   0.000     .2840035    .3844937
     tm_load |  -1.350727   .2478264    -5.45   0.000    -1.896189   -.8052644
       _cons |   11.18505   .3660016    30.56   0.000     10.37949    11.99062
------------------------------------------------------------------------------

.
.
.
. /***********************************************/
. // Two way fixed group and time effect model
. /***********************************************/
```

```
. use "airline.dta", clear

.
. /***************************************************/
. // LSDV1: Without two dummy variables
.
. regress cost g1-g5 t1-t14 output fuel load // LSDV1

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F( 22,    67) = 1960.82
       Model |  113.864044    22  5.17563838           Prob > F      =  0.0000
    Residual |  .176848775    67  .002639534           R-squared     =  0.9984
-------------+------------------------------           Adj R-squared =  0.9979
       Total |  114.040893    89  1.28135835           Root MSE      =  .05138

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |   .1742825   .0861201     2.02   0.047     .0023861     .346179
          g2 |   .1114508   .0779551     1.43   0.157    -.0441482    .2670499
          g3 |   -.143511   .0518934    -2.77   0.007    -.2470907   -.0399313
          g4 |   .1802087   .0321443     5.61   0.000     .1160484    .2443691
          g5 |  -.0466942   .0224688    -2.08   0.042    -.0915422   -.0018463
          t1 |  -.6931382   .3378385    -2.05   0.044    -1.367467   -.0188098
          t2 |  -.6384366   .3320802    -1.92   0.059    -1.301271    .0243983
          t3 |  -.5958031   .3294473    -1.81   0.075    -1.253383    .0617764
          t4 |  -.5421537   .3189139    -1.70   0.094    -1.178708    .0944011
          t5 |  -.4730429   .2319459    -2.04   0.045    -.9360088   -.0100769
          t6 |  -.4272042     .18844    -2.27   0.027    -.8033319   -.0510764
          t7 |  -.3959783   .1732969    -2.28   0.025    -.7418804   -.0500762
          t8 |  -.3398463   .1501062    -2.26   0.027    -.6394596    -.040233
          t9 |  -.2718933   .1348175    -2.02   0.048    -.5409901   -.0027964
         t10 |  -.2273857   .0763495    -2.98   0.004      -.37978   -.0749914
         t11 |  -.1118032   .0319005    -3.50   0.001     -.175477   -.0481295
         t12 |   -.033641   .0429008    -0.78   0.436    -.1192713    .0519893
         t13 |  -.0177346   .0362554    -0.49   0.626    -.0901007    .0546315
         t14 |  -.0186451    .030508    -0.61   0.543    -.0795393     .042249
      output |   .8172487    .031851    25.66   0.000     .7536739    .8808235
        fuel |     .16861    .163478     1.03   0.306    -.1576935    .4949135
        load |  -.8828142   .2617373    -3.37   0.001    -1.405244   -.3603843
       _cons |   12.94004   2.218231     5.83   0.000     8.512434    17.36765
------------------------------------------------------------------------------

. predict gte, resid

. test g1 g2 g3 g4 g5 t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11 t12 t13 t14

 ( 1)  g1 = 0
 ( 2)  g2 = 0
 ( 3)  g3 = 0
 ( 4)  g4 = 0
 ( 5)  g5 = 0
 ( 6)  t1 = 0
 ( 7)  t2 = 0
 ( 8)  t3 = 0
 ( 9)  t4 = 0
 (10)  t5 = 0
 (11)  t6 = 0
 (12)  t7 = 0
 (13)  t8 = 0
 (14)  t9 = 0
 (15)  t10 = 0
 (16)  t11 = 0
 (17)  t12 = 0
 (18)  t13 = 0
 (19)  t14 = 0
```

```
       F( 19,    67) =   23.10
            Prob > F =    0.0000

.
.
. // LSDV1 + LSDV3: Dropping a dummy and imposing a restriction
. // constraint define 2 g1 + g2 + g3 + g4 + g5 + g6 = 0
. cnsreg cost g1-g6 t1-t14 output fuel load, constraint(2)

Constrained linear regression                   Number of obs =      90
                                                F( 22,    67) = 1960.82
                                                Prob > F      =  0.0000
                                                Root MSE      =  .05138

 ( 1)  g1 + g2 + g3 + g4 + g5 + g6 = 0
------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |   .1283264   .0460126     2.79   0.007     .0364849    .2201679
          g2 |   .0654947   .0389685     1.68   0.097    -.0122867    .1432761
          g3 |  -.1894671   .0156096   -12.14   0.000     -.220624   -.1583102
          g4 |   .1342526   .0183163     7.33   0.000      .097693    .1708121
          g5 |  -.0926504   .0373085    -2.48   0.016    -.1671184   -.0181824
          g6 |  -.0459561   .0416069    -1.10   0.273    -.1290038    .0370916
          t1 |  -.6931382   .3378385    -2.05   0.044    -1.367467   -.0188098
          t2 |  -.6384366   .3320802    -1.92   0.059    -1.301271    .0243983
          t3 |  -.5958031   .3294473    -1.81   0.075    -1.253383    .0617764
          t4 |  -.5421537   .3189139    -1.70   0.094    -1.178708    .0944011
          t5 |  -.4730429   .2319459    -2.04   0.045    -.9360088   -.0100769
          t6 |  -.4272042     .18844    -2.27   0.027    -.8033319   -.0510764
          t7 |  -.3959783   .1732969    -2.28   0.025    -.7418804   -.0500762
          t8 |  -.3398463   .1501062    -2.26   0.027    -.6394596    -.040233
          t9 |  -.2718933   .1348175    -2.02   0.048    -.5409901   -.0027964
         t10 |  -.2273857   .0763495    -2.98   0.004      -.37978   -.0749914
         t11 |  -.1118032   .0319005    -3.50   0.001     -.175477   -.0481295
         t12 |   -.033641   .0429008    -0.78   0.436    -.1192713    .0519893
         t13 |  -.0177346   .0362554    -0.49   0.626    -.0901007    .0546315
         t14 |  -.0186451    .030508    -0.61   0.543    -.0795393     .042249
      output |   .8172487    .031851    25.66   0.000     .7536739    .8808235
        fuel |     .16861    .163478     1.03   0.306    -.1576935    .4949135
        load |  -.8828142   .2617373    -3.37   0.001    -1.405244   -.3603843
       _cons |     12.986   2.225402     5.84   0.000     8.544076    17.42792
------------------------------------------------------------------------------

.
.
. // constraint define 3 t1+t2+t3+t4+t5+t6+t7+t8+t9+t10+t11+t12+t13+t14+t15=0
. cnsreg cost g1-g5 t1-t15 output fuel load, constraint(3)

Constrained linear regression                   Number of obs =      90
                                                F( 22,    67) = 1960.82
                                                Prob > F      =  0.0000
                                                Root MSE      =  .05138

 ( 1)  t1 + t2 + t3 + t4 + t5 + t6 + t7 + t8 + t9 + t10 + t11 + t12 + t13 + t14 +
t15 = 0
------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |   .1742825   .0861201     2.02   0.047     .0023861     .346179
          g2 |   .1114508   .0779551     1.43   0.157    -.0441482    .2670499
          g3 |   -.143511   .0518934    -2.77   0.007    -.2470907   -.0399313
          g4 |   .1802087   .0321443     5.61   0.000     .1160484    .2443691
          g5 |  -.0466942   .0224688    -2.08   0.042    -.0915422   -.0018463
          t1 |  -.3740245    .191872    -1.95   0.055    -.7570026    .0089536
          t2 |  -.3193228   .1860877    -1.72   0.091    -.6907554    .0521097
          t3 |  -.2766893   .1833501    -1.51   0.136    -.6426576    .0892789
          t4 |  -.2230399   .1729671    -1.29   0.202    -.5682837    .1222038
          t5 |  -.1539291   .0864404    -1.78   0.079    -.3264649    .0186066
```

```
          t6 |  -.1080904   .0448591    -2.41   0.019    -.1976296   -.0185513
          t7 |  -.0768646   .0319336    -2.41   0.019    -.1406043   -.0131248
          t8 |  -.0207326   .0204506    -1.01   0.314     -.061552    .0200869
          t9 |   .0472205   .0290822     1.62   0.109    -.0108278    .1052688
         t10 |   .0917281   .0811525     1.13   0.262    -.0702531    .2537092
         t11 |   .2073105   .1491443     1.39   0.169    -.0903829    .5050039
         t12 |   .2854727   .1756365     1.63   0.109    -.0650993    .6360447
         t13 |   .3013791   .1660294     1.82   0.074     -.030017    .6327752
         t14 |   .3004686   .1536212     1.96   0.055    -.0061606    .6070978
         t15 |   .3191137   .1474883     2.16   0.034     .0247259    .6135015
      output |   .8172487    .031851    25.66   0.000     .7536739    .8808235
        fuel |     .16861    .163478     1.03   0.306    -.1576935    .4949135
        load |  -.8828142   .2617373    -3.37   0.001    -1.405244   -.3603843
       _cons |   12.62093   2.074302     6.08   0.000     8.480603    16.76125
------------------------------------------------------------------------------

.
.
. // 'LSDV3: With a restriciton';
. // constraint define 2 g1 + g2 + g3 + g4 + g5 + g6 = 0
. // constraint define 3 t1+t2+t3+t4+t5+t6+t7+t8+t9+t10+t11+t12+t13+t14+t15=0
. cnsreg cost g1-g6 t1-t15 output fuel load, constraint(2 3)

Constrained linear regression                   Number of obs =      90
                                                F( 22,    67) = 1960.82
                                                Prob > F      =  0.0000
                                                Root MSE      =  .05138
 ( 1)  g1 + g2 + g3 + g4 + g5 + g6 = 0
 ( 2)  t1 + t2 + t3 + t4 + t5 + t6 + t7 + t8 + t9 + t10 + t11 + t12 + t13 + t14 +
t15 = 0
------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          g1 |   .1283264   .0460126     2.79   0.007     .0364849    .2201679
          g2 |   .0654947   .0389685     1.68   0.097    -.0122867    .1432761
          g3 |  -.1894671   .0156096   -12.14   0.000     -.220624   -.1583102
          g4 |   .1342526   .0183163     7.33   0.000      .097693    .1708121
          g5 |  -.0926504   .0373085    -2.48   0.016    -.1671184   -.0181824
          g6 |  -.0459561   .0416069    -1.10   0.273    -.1290038    .0370916
          t1 |  -.3740245    .191872    -1.95   0.055    -.7570026    .0089536
          t2 |  -.3193228   .1860877    -1.72   0.091    -.6907554    .0521097
          t3 |  -.2766893   .1833501    -1.51   0.136    -.6426576    .0892789
          t4 |  -.2230399   .1729671    -1.29   0.202    -.5682837    .1222038
          t5 |  -.1539291   .0864404    -1.78   0.079    -.3264649    .0186066
          t6 |  -.1080904   .0448591    -2.41   0.019    -.1976296   -.0185513
          t7 |  -.0768646   .0319336    -2.41   0.019    -.1406043   -.0131248
          t8 |  -.0207326   .0204506    -1.01   0.314     -.061552    .0200869
          t9 |   .0472205   .0290822     1.62   0.109    -.0108278    .1052688
         t10 |   .0917281   .0811525     1.13   0.262    -.0702531    .2537092
         t11 |   .2073105   .1491443     1.39   0.169    -.0903829    .5050039
         t12 |   .2854727   .1756365     1.63   0.109    -.0650993    .6360447
         t13 |   .3013791   .1660294     1.82   0.074     -.030017    .6327752
         t14 |   .3004686   .1536212     1.96   0.055    -.0061606    .6070978
         t15 |   .3191137   .1474883     2.16   0.034     .0247259    .6135015
      output |   .8172487    .031851    25.66   0.000     .7536739    .8808235
        fuel |     .16861    .163478     1.03   0.306    -.1576935    .4949135
        load |  -.8828142   .2617373    -3.37   0.001    -1.405244   -.3603843
       _cons |   12.66688   2.081068     6.09   0.000     8.513054    16.82071
------------------------------------------------------------------------------

.
.
. /***********************************************/
. // Within Effect Model
.
. egen m_cost = mean(cost) // compute overall means
```

```
. egen m_output = mean(output)

. egen m_fuel = mean(fuel)

. egen m_load = mean(load)

.
. tabstat cost output fuel load, stat(mean)

   stats |      cost    output      fuel      load
---------+----------------------------------------
    mean |  13.36561 -1.174309  12.77036  .5604602
------------------------------------------------

.
. // data transformation
.
. gen w_cost = cost - gm_cost - tm_cost + m_cost // transform variables

. gen w_output = output - gm_output - tm_output + m_output

. gen w_fuel = fuel - gm_fuel - tm_fuel + m_fuel

. gen w_load = load - gm_load - tm_load + m_load

.
. save "airline.dta", replace
file airline.dta saved

.
. regress w_cost w_output w_fuel w_load, noc // within effect using .regress

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  3,    87) =  307.86
       Model |  1.87739643     3  .625798811           Prob > F      =  0.0000
    Residual |  .176848774    87  .002032745           R-squared     =  0.9139
-------------+------------------------------           Adj R-squared =  0.9109
       Total |  2.05424521    90  .022824947           Root MSE      =  .04509

------------------------------------------------------------------------------
      w_cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    w_output |   .8172487   .0279512    29.24   0.000     .7616927    .8728048
      w_fuel |     .16861   .1434621     1.18   0.243    -.1165364    .4537565
      w_load |  -.8828142   .2296907    -3.84   0.000    -1.339349    -.426279
------------------------------------------------------------------------------


.
.
. /***********************************************/
. // One way random group effect model
. /***********************************************/
. use "airline.dta", clear

.
. egen m_ge=mean(ge), by(airline) // compute group error means

. tab airline m_ge

           |                                    m_ge
   airline | -3.56e-07  -2.24e-07  -6.90e-08  -1.32e-08   1.81e-07   4.24e-07 |
Total
-----------+------------------------------------------------------------------
+----------
         1 |         0          0          0          0         15          0 |
15
```

```
        2 |         0          0          0         15          0          0 |
15
        3 |         0          0          0          0          0         15 |
15
        4 |         0         15          0          0          0          0 |
15
        5 |        15          0          0          0          0          0 |
15
        6 |         0          0         15          0          0          0 |
15
----------+------------------------------------------------------------------
+----------
    Total |        15         15         15         15         15         15 |
90


. gen d_ge2=(ge-m_ge)^2 // compute squared deviations from the group error means

.
. tabstat d_ge2, stat(sum) // sum of the squared deviatins

    variable |       sum
-------------+----------
       d_ge2 |  .2926229
-----------------------

. // this returns .2926229 that is equivalent to SSE of LSDV1 and the within effect
model
.
. di "sigma_error2: " .292622872/(6*15-6-3) // from SSE (ee) of LSDV1 (n*T-n-k)
sigma_error2: .00361263

. di "sigma_between2: " .031675926/(6-4)- .00361263/15 // from SSE of the between
effect
sigma_between2: .01559712

. di "theta: " 1-sqrt((.292622872/(6*15-6-3))/(15*(.031675926/(6-4))))
theta: .87668488

. // We get the theta of .87668488
.
. gen rg_cost = cost - .87668488*gm_cost // transform variables

. gen rg_output = output - .87668488*gm_output

. gen rg_fuel = fuel - .87668488*gm_fuel

. gen rg_load = load - .87668488*gm_load

. gen rg_int = 1 - .87668488 // for the intercept

.
. save "airline.dta", replace
file airline.dta saved


.
. regress rg_cost rg_int rg_output rg_fuel rg_load, noc // one-way random group
effect

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  4,    86) =19642.72
       Model |  284.670313     4  71.1675783           Prob > F      =  0.0000
    Residual |  .311586777    86  .003623102           R-squared     =  0.9989
-------------+------------------------------           Adj R-squared =  0.9989
       Total |    284.9819    90  3.16646556           Root MSE      =  .06019

------------------------------------------------------------------------------
```

```
     rg_cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      rg_int |   9.627911   .2101638    45.81   0.000     9.210119     10.0457
   rg_output |   .9066808   .0256249    35.38   0.000     .8557401    .9576215
     rg_fuel |   .4227784   .0140248    30.15   0.000      .394898    .4506587
     rg_load |    -1.0645   .2000703    -5.32   0.000    -1.462226   -.6667731
------------------------------------------------------------------------------

.
.
. // testing one-way random group effect
. collapse (mean) gm_resid=resid, by(airline)

. gen gm_resid2=gm_resid^2

.
. list, sep(10) noobs // list time means of variables

  +--------------------------------+
  | airline    gm_resid   gm_res~2 |
  |--------------------------------|
  |       1    .0688689   .0047429 |
  |       2   -.0138781   .0001926 |
  |       3   -.1942235   .0377228 |
  |       4    .1527256   .0233251 |
  |       5   -.0215835   .0004658 |
  |       6    .0080906   .0000655 |
  +--------------------------------+

. tabstat gm_resid2, stat(sum) //.0665147

    variable |       sum
-------------+----------
   gm_resid2 |  .0665147
-------------------------

.
. di (6*15)/(2*(15-1))*(15^2*.0665147/1.33544153-1)^2 // 334.84958
334.84958

. di chi2tail(1, 334.84958) // .0000
8.444e-75

.
.
.
.
. /***********************************************/
. //'One way random time effect model';
. // '===============================================';
. use "airline.dta", clear

.
. egen m_te=mean(te), by(year) // compute time error means

. tab airline m_te

           |                                                         m_te
   airline | -1.86e-09  -1.55e-09  -8.93e-10  -6.21e-10  -3.10e-10   2.33e-10
3.10e-10   4.66e-10   5.43e-10   5.63e-10 |     Total
-----------
+-----------------------------------------------------------------------------------------
---------------------------+----------
         1 |         1          1          1          1          1          1          1
1          1          1          1          1 |        15
         2 |         1          1          1          1          1          1          1
1          1          1          1          1 |        15
```

```
         3 |         1          1          1          1          1          1
1          1          1          1 |        15
         4 |         1          1          1          1          1          1
1          1          1          1 |        15
         5 |         1          1          1          1          1          1
1          1          1          1 |        15
         6 |         1          1          1          1          1          1
1          1          1          1 |        15
-----------
+-----------------------------------------------------------------------------------
---------------------------+----------
     Total |         6          6          6          6          6          6
6          6          6          6 |        90


           |                          m_te
   airline |  6.21e-10   7.76e-10   1.51e-09   1.55e-09   1.71e-09 |     Total
-----------+---------------------------------------------------------+----------
         1 |         1          1          1          1          1 |        15
         2 |         1          1          1          1          1 |        15
         3 |         1          1          1          1          1 |        15
         4 |         1          1          1          1          1 |        15
         5 |         1          1          1          1          1 |        15
         6 |         1          1          1          1          1 |        15
-----------+---------------------------------------------------------+----------
     Total |         6          6          6          6          6 |        90


. gen d_te2=(te-m_te)^2 // compute squared deviations from the time error means

.
. tabstat d_te2, stat(sum) // sum of the squared deviatins

    variable |       sum
-------------+----------
       d_te2 |   1.08819
------------------------

. // this returns 1.08819 that is equivalent to SSE of LSDV1 and the within effect
model
.
. di "sigma_error2: " 1.08819022/(6*15-15-3) // from SSE (ee) of LSDV1 (n*T-n-k)
sigma_error2: .01511375

. di "sigma_between2: " .005590631/(15-4)- .01511375/6 // from SSE of the between
effect
sigma_between2: -.00201072

. di "theta: " 1-sqrt((1.08819022/(6*15-15-3))/(6*(.005590631/(15-4))))
theta: -1.226263

. // We get the theta of -1.226263
.
. gen rt_cost = cost - (-1.226263)*tm_cost // transform variables

. gen rt_output = output - (-1.226263)*tm_output

. gen rt_fuel = fuel - (-1.226263)*tm_fuel

. gen rt_load = load - (-1.226263)*tm_load

. gen rt_int = 1 - (-1.226263) // for the intercept

.
. save "airline.dta", replace
file airline.dta saved
```

```
.
. regress rt_cost rt_int rt_output rt_fuel rt_load, noc // one-way random time
effect

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  4,    86) =       .
       Model |  79944.1804     4  19986.0451           Prob > F      =  0.0000
    Residual |  1.79271995    86  .020845581           R-squared     =  1.0000
-------------+------------------------------           Adj R-squared =  1.0000
       Total |  79945.9732    90  888.288591           Root MSE      =  .14438

------------------------------------------------------------------------------
     rt_cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      rt_int |   9.516098   .1489281    63.90   0.000     9.220038    9.812157
   rt_output |   .8883838   .0143338    61.98   0.000     .8598891    .9168785
     rt_fuel |   .4392731   .0129051    34.04   0.000     .4136186    .4649277
     rt_load |  -1.279176   .2482869    -5.15   0.000    -1.772754   -.7855982
------------------------------------------------------------------------------


.
.
. // testing onw-way random time effect
. collapse (mean) tm_resid=resid, by(year)

. gen tm_n_r2=(6*tm_resid)^2

.
. list, sep(20) noobs // list time means of variables

  +-----------------------------+
  | year    tm_resid    tm_n_r2 |
  |-----------------------------|
  |    1    -.070761   .1802564 |
  |    2   -.0224361   .0181217 |
  |    3    .0348638   .0437575 |
  |    4    .0641188   .1480038 |
  |    5    .0062456   .0014043 |
  |    6    -.032211   .0373517 |
  |    7   -.0273938   .0270152 |
  |    8   -.0118679   .0050705 |
  |    9    .0570991    .117371 |
  |   10   -.0109054   .0042814 |
  |   11   -.0491419   .0869374 |
  |   12   -.0165303   .0098371 |
  |   13    .0088047   .0027908 |
  |   14    .0226709   .0185029 |
  |   15    .0474445   .0810354 |
  +-----------------------------+

. tabstat tm_n_r2, stat(sum) //.7817371

    variable |       sum
-------------+----------
     tm_n_r2 |  .7817371
-----------------------

.
. di (15*6)/(2*(6-1))*(.7817371/1.33544153-1)^2 // 1.5472082
1.5472082

. di chi2tail(1, 1.5472121) // .21354748
.21354748

.
.
. /* double-check
```

```
> gen tm_resid2=tm_resid^2
> tabstat tm_resid2, stat(sum) //.0217149
> di (15*6)/(2*(6-1))*(6^2*.0217149/1.33544153-1)^2 // 1.5472121
> */
.
.
. /***********************************************/
. // Poolability Test
. // '============================================='
. use "airline.dta", clear

.
. regress cost output fuel load // pooled OLS

      Source |       SS       df       MS              Number of obs =      90
-------------+------------------------------           F(  3,    86) = 2419.34
       Model |  112.705452     3  37.5684839           Prob > F      =  0.0000
    Residual |  1.33544153    86   .01552839           R-squared     =  0.9883
-------------+------------------------------           Adj R-squared =  0.9879
       Total |  114.040893    89  1.28135835           Root MSE      =  .12461

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8827385   .0132545    66.60   0.000     .8563895    .9090876
        fuel |    .453977   .0203042    22.36   0.000     .4136136    .4943404
        load |   -1.62751    .345302    -4.71   0.000    -2.313948   -.9410727
       _cons |   9.516923   .2292445    41.51   0.000       9.0612    9.972645
------------------------------------------------------------------------------

.
.
. forvalues i= 1(1)6 { // run group by group regression
  2.    display "OLS regression for group " `i'
  3.    regress cost output fuel load if airline==`i'
  4. }
OLS regression for group 1

      Source |       SS       df       MS              Number of obs =      15
-------------+------------------------------           F(  3,    11) = 1843.46
       Model |  3.41824348     3  1.13941449           Prob > F      =  0.0000
    Residual |  .006798918    11  .000618083           R-squared     =  0.9980
-------------+------------------------------           Adj R-squared =  0.9975
       Total |   3.4250424    14  .244645886           Root MSE      =  .02486

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |    1.18318   .0968946    12.21   0.000     .9699164    1.396444
        fuel |   .3865867   .0181946    21.25   0.000     .3465406    .4266329
        load |  -2.461629   .4013571    -6.13   0.000     -3.34501   -1.578248
       _cons |     10.846   .2972551    36.49   0.000     10.19174    11.50025
------------------------------------------------------------------------------
OLS regression for group 2

      Source |       SS       df       MS              Number of obs =      15
-------------+------------------------------           F(  3,    11) = 3129.50
       Model |  6.47622084     3  2.15874028           Prob > F      =  0.0000
    Residual |  .007587838    11  .000689803           R-squared     =  0.9988
-------------+------------------------------           Adj R-squared =  0.9985
       Total |  6.48380868    14  .463129191           Root MSE      =  .02626

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   1.459104   .0792856    18.40   0.000     1.284597     1.63361
        fuel |   .3088958   .0272443    11.34   0.000     .2489315      .36886
```

```
        load |  -2.724785   .2376522   -11.47   0.000    -3.247854   -2.201716
       _cons |   11.97243   .4320951    27.71   0.000     11.02139    12.92346
------------------------------------------------------------------------------
OLS regression for group 3

      Source |       SS       df       MS              Number of obs =      15
-------------+------------------------------           F(  3,    11) =  608.10
       Model |  3.79286673     3  1.26428891           Prob > F      =  0.0000
    Residual |  .022869767    11   .00207907           R-squared     =  0.9940
-------------+------------------------------           Adj R-squared =  0.9924
       Total |   3.8157365    14  .272552607           Root MSE      =   .0456

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .7268305   .1554418     4.68   0.001     .3847054    1.068956
        fuel |   .4515127   .0381103    11.85   0.000     .3676324    .5353929
        load |  -.7513069   .6105989    -1.23   0.244    -2.095226    .5926122
       _cons |   8.699815   .8985786     9.68   0.000     6.722057    10.67757
------------------------------------------------------------------------------
OLS regression for group 4

      Source |       SS       df       MS              Number of obs =      15
-------------+------------------------------           F(  3,    11) =  777.86
       Model |  7.37252558     3  2.45750853           Prob > F      =  0.0000
    Residual |  .034752343    11  .003159304           R-squared     =  0.9953
-------------+------------------------------           Adj R-squared =  0.9940
       Total |  7.40727792    14   .52909128           Root MSE      =  .05621

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .9353749   .0759266    12.32   0.000     .7682616    1.102488
        fuel |   .4637263    .044347    10.46   0.000     .3661192    .5613333
        load |  -.7756708   .4707826    -1.65   0.128    -1.811856    .2605148
       _cons |   9.164608   .6023241    15.22   0.000     7.838902    10.49031
------------------------------------------------------------------------------
OLS regression for group 5

      Source |       SS       df       MS              Number of obs =      15
-------------+------------------------------           F(  3,    11) = 1999.89
       Model |  7.08313716     3  2.36104572           Prob > F      =  0.0000
    Residual |  .012986435    11  .001180585           R-squared     =  0.9982
-------------+------------------------------           Adj R-squared =  0.9977
       Total |  7.09612359    14  .506865971           Root MSE      =  .03436

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   1.076299   .0771255    13.96   0.000     .9065471    1.246051
        fuel |   .2920542   .0434213     6.73   0.000     .1964845    .3876239
        load |  -1.206847   .3336308    -3.62   0.004    -1.941163   -.4725305
       _cons |   11.77079   .7430078    15.84   0.000     10.13544    13.40614
------------------------------------------------------------------------------
OLS regression for group 6

      Source |       SS       df       MS              Number of obs =      15
-------------+------------------------------           F(  3,    11) = 2602.49
       Model |  11.1173565     3  3.70578551           Prob > F      =  0.0000
    Residual |  .015663323    11  .001423938           R-squared     =  0.9986
-------------+------------------------------           Adj R-squared =  0.9982
       Total |  11.1330199    14  .795215705           Root MSE      =  .03774

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .9673393   .0321728    30.07   0.000     .8965275    1.038151
```

```
        fuel |   .3023258   .0308235     9.81   0.000     .2344839    .3701678
        load |   .1050328   .4767508     0.22   0.830    -.9442886    1.154354
       _cons |   10.77381   .4095921    26.30   0.000     9.872309    11.67532
------------------------------------------------------------------------------

.
.
. di .006798918 + .007587838 + .022869767 + .034752343 + .012986435 + .015663323
.10065862

.
. di (1.33544153-.10065862)/((6-1)*4)/(.10065862)*(6*(15-4))
40.481219

.
. di "df1: " (6-1)*4 " df2: " 6*(15-4)
df1: 20 df2: 66

.
. di Ftail(20,66, 40.481219)
1.999e-29

.
.
.
.
. forvalues t= 1(1)15 { // run time by time regression
  2.     display "OLS regression for time " `t'
  3.     regress cost output fuel load if year==`t'
  4. }
OLS regression for time 1

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   87.78
       Model |  5.89988662     3  1.96662887           Prob > F      =  0.0113
    Residual |  .044807673     2  .022403836           R-squared     =  0.9925
-------------+------------------------------           Adj R-squared =  0.9812
       Total |  5.94469429     5  1.18893886           Root MSE      =  .14968

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8438949   .2192032     3.85   0.061    -.0992604     1.78705
        fuel |  -.7155383   2.768264    -0.26   0.820    -12.62642    11.19534
        load |  -1.388182   4.572022    -0.30   0.790       -21.06    18.28364
       _cons |   22.87057   30.26533     0.76   0.529    -107.3506    153.0917
------------------------------------------------------------------------------
OLS regression for time 2

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =  171.23
       Model |  5.93158231     3   1.9771941           Prob > F      =  0.0058
    Residual |  .023093978     2  .011546989           R-squared     =  0.9961
-------------+------------------------------           Adj R-squared =  0.9903
       Total |  5.95467628     5  1.19093526           Root MSE      =  .10746

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8268285   .0653822    12.65   0.006     .5455114    1.108146
        fuel |  -1.396219   1.465308    -0.95   0.441    -7.700929    4.908491
        load |  -.8998671   1.755662    -0.51   0.659    -8.453873    6.654138
       _cons |   30.63206   16.64829     1.84   0.207    -40.99975    102.2639
------------------------------------------------------------------------------
OLS regression for time 3

      Source |       SS       df       MS              Number of obs =       6
```

```
-------------+------------------------------           F(  3,     2) =  241.91
       Model |  5.98966713     3  1.99655571           Prob > F      =  0.0041
    Residual |  .016506613     2  .008253307           R-squared     =  0.9973
-------------+------------------------------           Adj R-squared =  0.9931
       Total |  6.00617375     5  1.20123475           Root MSE      =  .09085

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8611228   .0350731    24.55   0.002     .7102152     1.01203
        fuel |  -1.036776   1.074723    -0.96   0.436    -5.660935    3.587384
        load |  -2.602187    1.27224    -2.05   0.177    -8.076193    2.871818
       _cons |   27.43246    12.4929     2.20   0.159    -26.32015    81.18506
------------------------------------------------------------------------------
OLS regression for time 4

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =  333.28
       Model |  6.08422217     3  2.02807406           Prob > F      =  0.0030
    Residual |  .012170358     2  .006085179           R-squared     =  0.9980
-------------+------------------------------           Adj R-squared =  0.9950
       Total |  6.09639252     5   1.2192785           Root MSE      =  .07801

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |    .906854   .0409274    22.16   0.002     .7307576     1.08295
        fuel |    .757728   1.095969     0.69   0.561    -3.957847    5.473303
        load |  -4.250021    1.48134    -2.87   0.103    -10.62371    2.123671
       _cons |   7.427644   12.31178     0.60   0.608    -45.54569    60.40098
------------------------------------------------------------------------------
OLS regression for time 5

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =  277.91
       Model |  5.87960068     3  1.95986689           Prob > F      =  0.0036
    Residual |  .014104542     2  .007052271           R-squared     =  0.9976
-------------+------------------------------           Adj R-squared =  0.9940
       Total |  5.89370522     5  1.17874104           Root MSE      =  .08398

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .9252074   .0455721    20.30   0.002     .7291264    1.121288
        fuel |  -.0864512   .5278954    -0.16   0.885    -2.357802      2.1849
        load |  -4.316237    1.80898    -2.39   0.140    -12.09965    3.467173
       _cons |   17.72792   6.029795     2.94   0.099    -8.216193    43.67203
------------------------------------------------------------------------------
OLS regression for time 6

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) = 8265.94
       Model |   5.8253318     3  1.94177727           Prob > F      =  0.0001
    Residual |  .000469826     2  .000234913           R-squared     =  0.9999
-------------+------------------------------           Adj R-squared =  0.9998
       Total |  5.82580163     5  1.16516033           Root MSE      =  .01533

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .9011403   .0073568   122.49   0.000     .8694865    .9327941
        fuel |  -1.203662   .1506967    -7.99   0.015    -1.852057   -.5552664
        load |  -4.659205   .2468834   -18.87   0.003    -5.721459   -3.596952
       _cons |   31.97436   1.930633    16.56   0.004     23.66752     40.2812
------------------------------------------------------------------------------
OLS regression for time 7
```

```
      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   59.49
       Model |  5.67946753     3  1.89315584           Prob > F      =  0.0166
    Residual |  .063648817     2  .031824408           R-squared     =  0.9889
-------------+------------------------------           Adj R-squared =  0.9723
       Total |  5.74311634     5  1.14862327           Root MSE      =  .17839

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8509165    .111318     7.64   0.017     .3719537    1.329879
        fuel |  -1.146308   1.916209    -0.60   0.610    -9.391091    7.098476
        load |  -4.275049   4.087954    -1.05   0.405     -21.8641      13.314
       _cons |   31.13968   25.01033     1.25   0.339    -76.47108    138.7504
------------------------------------------------------------------------------
OLS regression for time 8

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   43.55
       Model |  5.58065893     3  1.86021964           Prob > F      =  0.0225
    Residual |  .085430285     2  .042715143           R-squared     =  0.9849
-------------+------------------------------           Adj R-squared =  0.9623
       Total |  5.66608922     5  1.13321784           Root MSE      =  .20668

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8363979   .1239824     6.75   0.021     .3029448    1.369851
        fuel |  -1.364656   2.878571    -0.47   0.682    -13.75015    11.02083
        load |  -3.372375   4.823993    -0.70   0.557    -24.12834    17.38359
       _cons |   33.65754   37.50191     0.90   0.464    -127.7001    195.0152
------------------------------------------------------------------------------
OLS regression for time 9

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   72.71
       Model |  5.37982691     3  1.79327564           Prob > F      =  0.0136
    Residual |  .049329439     2  .024664719           R-squared     =  0.9909
-------------+------------------------------           Adj R-squared =  0.9773
       Total |  5.42915635     5  1.08583127           Root MSE      =  .15705

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .9631849   .1122741     8.58   0.013     .4801085    1.446261
        fuel |   5.831466     5.1388     1.13   0.374    -16.27901    27.94194
        load |  -4.671755   2.845477    -1.64   0.242    -16.91486    7.571347
       _cons |  -57.61916   65.17573    -0.88   0.470    -338.0477    222.8094
------------------------------------------------------------------------------
OLS regression for time 10

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   43.05
       Model |  4.97981749     3  1.65993916           Prob > F      =  0.0228
    Residual |  .077112957     2  .038556478           R-squared     =  0.9848
-------------+------------------------------           Adj R-squared =  0.9619
       Total |  5.05693045     5  1.01138609           Root MSE      =  .19636

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8059424   .1225795     6.57   0.022     .2785254    1.333359
        fuel |  -1.824327   4.723984    -0.39   0.737    -22.14999    18.50134
        load |   .6773427   3.535927     0.19   0.866    -14.53652    15.89121
       _cons |   38.14601   62.51976     0.61   0.604    -230.8548    307.1468
------------------------------------------------------------------------------
OLS regression for time 11
```

```
      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =  103.49
       Model |  4.64372368     3  1.54790789           Prob > F      =  0.0096
    Residual |  .029913538     2  .014956769           R-squared     =  0.9936
-------------+------------------------------           Adj R-squared =  0.9840
       Total |  4.67363722     5  .934727444           Root MSE      =   .1223

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8021097   .0644276    12.45   0.006        .5249    1.079319
        fuel |   7.293176   5.019792     1.45   0.283    -14.30524     28.8916
        load |    3.59002   2.386906     1.50   0.271    -6.680008    13.86005
       _cons |  -87.07426   69.45653    -1.25   0.337    -385.9216    211.7731
------------------------------------------------------------------------------
OLS regression for time 12

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   29.73
       Model |  3.88995209     3   1.2966507           Prob > F      =  0.0327
    Residual |  .087240016     2  .043620008           R-squared     =  0.9781
-------------+------------------------------           Adj R-squared =  0.9452
       Total |  3.97719211     5  .795438422           Root MSE      =  .20885

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8013883   .1465708     5.47   0.032     .1707452    1.432032
        fuel |  -12.09356   20.71887    -0.58   0.618    -101.2396    77.05254
        load |  -2.944114   3.540697    -0.83   0.493     -18.1785    12.29027
       _cons |   183.6475   287.2236     0.64   0.588    -1052.176    1419.471
------------------------------------------------------------------------------
OLS regression for time 13

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   16.56
       Model |   3.5617239     3   1.1872413           Prob > F      =  0.0575
    Residual |  .143348297     2  .071674149           R-squared     =  0.9613
-------------+------------------------------           Adj R-squared =  0.9033
       Total |   3.7050722     5   .74101444           Root MSE      =  .26772

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8706385   .1308991     6.65   0.022     .3074253    1.433852
        fuel |  -.9052638   11.45206    -0.08   0.944    -50.17949    48.36897
        load |  -2.255954   3.333563    -0.68   0.568    -16.59912    12.08721
       _cons |   28.58371   157.0081     0.18   0.872    -646.9674    704.1348
------------------------------------------------------------------------------
OLS regression for time 14

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   33.63
       Model |  3.33339595     3  1.11113198           Prob > F      =  0.0290
    Residual |  .066075346     2  .033037673           R-squared     =  0.9806
-------------+------------------------------           Adj R-squared =  0.9514
       Total |   3.3994713     5  .679894259           Root MSE      =  .18176

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8804511   .1009537     8.72   0.013     .4460825     1.31482
        fuel |  -2.278843     5.4238    -0.42   0.715    -25.61557    21.05788
        load |  -.4755728   2.131136    -0.22   0.844    -9.645112    8.693967
       _cons |   46.23815   73.76981     0.63   0.595    -271.1677     363.644
------------------------------------------------------------------------------
```

```
OLS regression for time 15

      Source |       SS       df       MS              Number of obs =       6
-------------+------------------------------           F(  3,     2) =   59.49
       Model |  3.32476428     3  1.10825476           Prob > F      =  0.0166
    Residual |  .037256216     2  .018628108           R-squared     =  0.9889
-------------+------------------------------           Adj R-squared =  0.9723
       Total |  3.36202049     5  .672404098           Root MSE      =  .13648

------------------------------------------------------------------------------
        cost |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      output |   .8562932   .0885188     9.67   0.011     .4754273    1.237159
        fuel |  -8.999042   6.866784    -1.31   0.320    -38.54443    20.54635
        load |  -.1867014   1.708237    -0.11   0.923    -7.536651    7.163248
       _cons |   137.5589   92.93727     1.48   0.277    -262.3179    537.4357
------------------------------------------------------------------------------


. 
. di .044807673 + .023093978 + .016506613 + .012170358 + .014104542 + ///
>    .000469826 + .063648817 + .085430285 + .049329439 + .077112957 + ///
>    .029913538 + .087240016 + .143348297 + .066075346 + .037256216
.7505079

. 
. di (1.33544153-.7505079)/((15-1)*4)/(.7505079)*(15*(6-4))
.41752699

. 
. di "df1: " (15-1)*6 " df2: " 15*(6-4)
df1: 84 df2: 30

. 
. di Ftail(84,30, .41752699)
.99905119
```