Quantitative Methods in Finance

Tutorial, Part 15:
Static panel data analysis.

Example 1: Data on a group of American airlines are provided in Stata file `airlines.dta`. The following variables are available:

- *firm*: firm identifier;
- *time*: time identifier;
- *lq*: log of output (an index of passenger and freight miles);
- *lf*: log of fuel used;
- *lm*: log of materials used;
- *le*: log of equipment used;
- *ll*: log of labour employed;
- *lp*: log of property employed (other than equipment).

a) Load the data using the provided Stata data file. Explore the data using different panel structure Stata commands. Decompose the total variation of variables into "within" and "between" variation.
b) Estimate a production function specifying the log of output as a linear function of the logs of the five inputs. Obtain both the least-squares dummy variable and the fixed-effects panel data estimator. Do the results appear to be reasonable estimates of a production function? Explain. Then calculate the fixed effects.
c) Estimate the equation under b) by using the random-effects panel data estimator. Again, do the results appear to be reasonable estimates of a production function?
d) Should you deal with the firm effects as fixed effects or random effects? Explain with reference to particular test statistic.
e) Restrict the production function to exhibit constant returns to scale (sum of the elasticities equal to one). Test whether the restricted model is correct. What do you find?

Computer printout of the results in Stata:

```
a) Data exploration

. xtset firm time
       panel variable:  firm (unbalanced)
        time variable:  time, 1 to 15
                delta:  1 unit

. xtdes

    firm:  1, 2, ..., 10                                    n =         10
    time:  1, 2, ..., 15                                    T =         15
           Delta(time) = 1 unit
           Span(time)  = 15 periods
           (firm*time uniquely identifies each observation)
```

```
Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         7       7      11        14        14      15      15

     Freq.  Percent    Cum. |  Pattern
 ----------------------------+-----------------
        3     30.00   30.00 |  11111111111111.
        2     20.00   50.00 |  111111111111111
        1     10.00   60.00 |  1111111........
        1     10.00   70.00 |  1111111111.....
        1     10.00   80.00 |  11111111111....
        1     10.00   90.00 |  111111111111...
        1     10.00  100.00 |  1111111111111..
 ----------------------------+-----------------
       10    100.00         |  XXXXXXXXXXXXXXX
```

. xtsum lf-lq

```
Variable         |      Mean   Std. Dev.       Min        Max |    Observations
-----------------+--------------------------------------------+----------------
lf       overall | -.1977464   .5467627    -1.9861       .5709 |     N =     125
         between |             .5757858  -1.132471   .4343286 |     n =      10
         within  |             .1540943  -1.265616   .3058843 | T-bar =    12.5
                 |                                           |
lm       overall |  .0059136   .5850853    -1.7097       .8952 |     N =     125
         between |             .5965875   -.911475   .5541571 |     n =      10
         within  |             .2023754  -.9503941   .5654059 | T-bar =    12.5
                 |                                           |
le       overall | -.1316296   .6214353    -1.9193       .7443 |     N =     125
         between |             .6511147  -1.145186   .6402286 |     n =      10
         within  |             .1675224  -.9571142   .3962857 | T-bar =    12.5
                 |                                           |
ll       overall |   -.24276   .6270653    -1.8828       .5259 |     N =     125
         between |             .6730193  -1.337586   .4697429 |     n =      10
         within  |             .1393717  -1.092745   .1233554 | T-bar =    12.5
                 |                                           |
lp       overall |  -.143568    .688236       -1.7     1.0321 |     N =     125
         between |             .7088243  -1.284543      .7226 |     n =      10
         within  |             .2469366   -.589548   .5261474 | T-bar =    12.5
                 |                                           |
lq       overall | -.1553104   .6375828    -1.8298        .893 |     N =     125
         between |             .6336607  -1.146786   .5512286 |     n =      10
         within  |             .2642143  -1.034065   .5362434 | T-bar =    12.5
```

. xttab firm

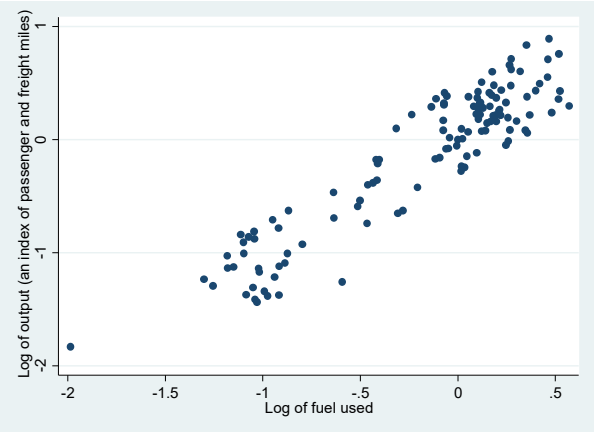
```
                 Overall            Between            Within
     firm |    Freq.  Percent      Freq.  Percent         Percent
----------+-----------------------------------------------------
        1 |      15     12.00          1     10.00          100.00
        2 |      13     10.40          1     10.00          100.00
        3 |      12      9.60          1     10.00          100.00
        4 |      15     12.00          1     10.00          100.00
        5 |      14     11.20          1     10.00          100.00
        6 |       7      5.60          1     10.00          100.00
        7 |      11      8.80          1     10.00          100.00
        8 |      10      8.00          1     10.00          100.00
        9 |      14     11.20          1     10.00          100.00
       10 |      14     11.20          1     10.00          100.00
----------+-----------------------------------------------------
    Total |     125    100.00         10    100.00          100.00
                              (n = 10)
```

. xttab time

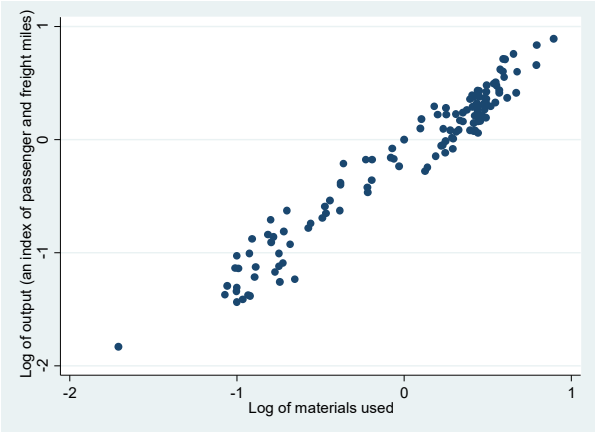
time	Overall Freq.	Overall Percent	Between Freq.	Between Percent	Within Percent
1	10	8.00	10	100.00	8.42
2	10	8.00	10	100.00	8.42
3	10	8.00	10	100.00	8.42
4	10	8.00	10	100.00	8.42
5	10	8.00	10	100.00	8.42
6	10	8.00	10	100.00	8.42
7	10	8.00	10	100.00	8.42
8	9	7.20	9	90.00	7.76
9	9	7.20	9	90.00	7.76
10	9	7.20	9	90.00	7.76
11	8	6.40	8	80.00	7.48
12	7	5.60	7	70.00	7.26
13	6	4.80	6	60.00	7.08
14	5	4.00	5	50.00	6.95
15	2	1.60	2	20.00	6.67
Total	125	100.00	125	1250.00	8.00
			(n = 10)		

b) LSDV/FE panel data estimation

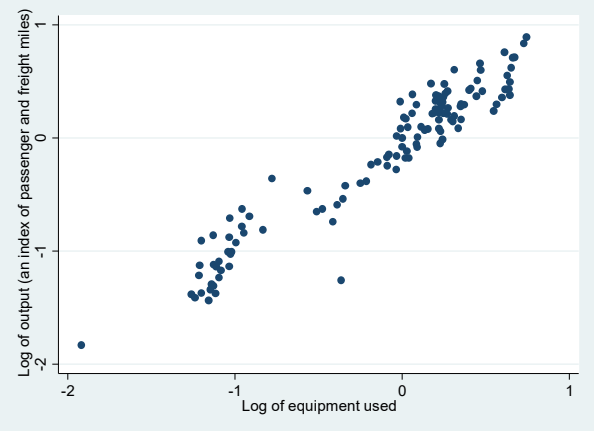
. scatter lq lf



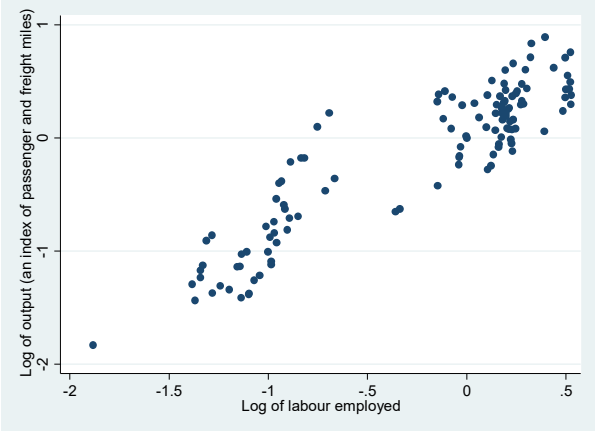
. scatter lq lm



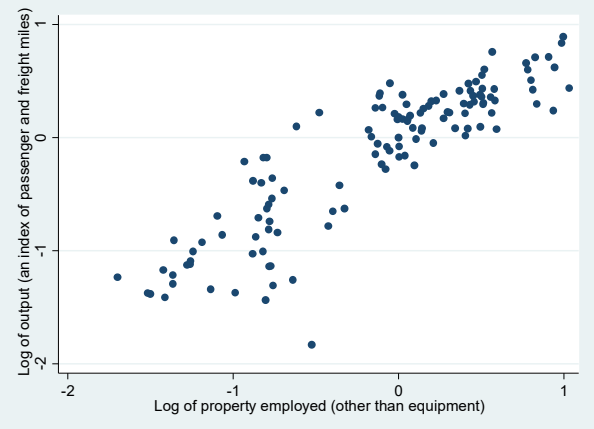
. scatter lq le



. scatter lq ll



```
. scatter lq lp
```




```
. xi: reg lq lf lm le ll lp i.firm

i.firm            _Ifirm_1-10         (naturally coded; _Ifirm_1 omitted)

      Source |       SS       df       MS              Number of obs =     125
-------------+------------------------------           F( 14,   110) =  281.71
       Model |   49.039708    14  3.50283628           Prob > F      =  0.0000
    Residual |  1.36776599   110  .012434236           R-squared     =  0.9729
-------------+------------------------------           Adj R-squared =  0.9694
       Total |   50.407474   124  .406511887           Root MSE      =  .11151

------------------------------------------------------------------------------
          lq |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          lf |   -.286072   .1447074    -1.98   0.051    -.5728481     .000704
          lm |   1.229901   .1166257    10.55   0.000     .9987766    1.461026
          le |   .0667291   .1494044     0.45   0.656    -.2293554    .3628135
          ll |   .0708771   .1771064     0.40   0.690    -.2801063    .4218605
          lp |   .0329359   .0495029     0.67   0.507    -.0651673     .131039
    _Ifirm_2 |   .0524382   .1224821     0.43   0.669    -.1902925    .2951689
    _Ifirm_3 |   .2346149   .1143365     2.05   0.043     .0080268    .4612029
    _Ifirm_4 |   .1528947   .0465448     3.28   0.001     .0606537    .2451356
    _Ifirm_5 |  -.0956372   .0489409    -1.95   0.053    -.1926267    .0013522
    _Ifirm_6 |   .0451795   .1479367     0.31   0.761    -.2479964    .3383553
    _Ifirm_7 |   .2417523   .1368994     1.77   0.080    -.0295502    .5130549
    _Ifirm_8 |  -.0453951   .0526543    -0.86   0.390    -.1497436    .0589533
    _Ifirm_9 |  -.0297066   .0449237    -0.66   0.510    -.1187348    .0593217
   _Ifirm_10 |   .1520238   .0568303     2.68   0.009     .0393994    .2646482
       _cons |  -.2579199   .0384603    -6.71   0.000    -.3341391   -.1817006
------------------------------------------------------------------------------
```

```
. xtreg lq lf lm le ll lp, fe

Fixed-effects (within) regression               Number of obs      =       125
Group variable: firm                            Number of groups   =        10

R-sq:  within  = 0.8420                         Obs per group: min =         7
       between = 0.9730                                        avg =      12.5
       overall = 0.9482                                        max =        15

                                                F(5,110)           =    117.23
corr(u_i, Xb)  = -0.4647                        Prob > F           =    0.0000
```

```
------------------------------------------------------------------------------
          lq |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          lf |   -.286072   .1447074    -1.98   0.051    -.5728481     .000704
          lm |   1.229901   .1166257    10.55   0.000     .9987766    1.461026
          le |   .0667291   .1494044     0.45   0.656    -.2293554    .3628135
          ll |   .0708771   .1771064     0.40   0.690    -.2801063    .4218605
          lp |   .0329359   .0495029     0.67   0.507    -.0651673     .131039
       _cons |  -.1884351   .0316659    -5.95   0.000    -.2511894   -.1256808
-------------+----------------------------------------------------------------
     sigma_u |  .11865322
     sigma_e |  .11150891
         rho |  .53101049   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(9, 110) =     5.43                 Prob > F = 0.0000
```

```
. by firm: egen mlq=mean(lq)
. by firm: egen mlf=mean(lf)
. by firm: egen mlm=mean(lm)
. by firm: egen mle=mean(le)
. by firm: egen mll=mean(ll)
. by firm: egen mlp=mean(lp)

. by firm: gen fe=mlq-_b[lf]*mlf-_b[lm]*mlm-_b[le]*mle-_b[ll]*mll-_b[lp]*mlp

. table firm, contents(mean fe)

----------------------
     Firm |   mean(fe)
----------+-----------
        1 |  -.2579198
        2 |  -.2054816
        3 |   -.023305
        4 |  -.1050252
        5 |  -.3535571
        6 |  -.2127404
        7 |  -.0161675
        8 |   -.303315
        9 |  -.2876264
       10 |  -.1058961
----------------------
```

c) RE panel data estimation

```
. xtreg lq lf lm le ll lp, re

Random-effects GLS regression                   Number of obs      =       125
Group variable: firm                            Number of groups   =        10

R-sq:  within  = 0.8248                         Obs per group: min =         7
       between = 0.9928                                        avg =      12.5
       overall = 0.9608                                        max =        15

Random effects u_i ~ Gaussian                   Wald chi2(5)       =   2917.14
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
          lq |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          lf |  -.1455064   .1250546    -1.16   0.245    -.3906089    .0995961
          lm |   .7881853    .080842     9.75   0.000     .6297378    .9466328
          le |   .4026248   .0870584     4.62   0.000     .2319935    .5732562
          ll |  -.1072489   .0917754    -1.17   0.243    -.2871254    .0726277
```

```
          lp |     .09627   .0429988     2.24   0.025     .0119939    .1805461
       _cons |  -.1479619   .0191727    -7.72   0.000    -.1855397   -.1103841
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  .11150891
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

d) The Hausman test

```
. qui xtreg lq lf lm le ll lp, fe
. estimates store fixed

. qui xtreg lq lf lm le ll lp, re
. estimates store random

. hausman fixed random

                 ---- Coefficients ----
              |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
              |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
          lf |    -.286072    -.1455064       -.1405657        .0728119
          lm |    1.229901     .7881853         .441716        .0840601
          le |    .0667291     .4026248       -.3358958        .1214187
          ll |    .0708771    -.1072489         .178126        .1514726
          lp |    .0329359       .09627       -.0633341        .0245284
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      103.79
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

e) Testing hypotheses

```
. xtreg lq lf lm le ll lp, fe

Fixed-effects (within) regression               Number of obs      =       125
Group variable: firm                            Number of groups   =        10

R-sq:  within  = 0.8420                         Obs per group: min =         7
       between = 0.9730                                        avg =      12.5
       overall = 0.9482                                        max =        15

                                                F(5,110)           =    117.23
corr(u_i, Xb)  = -0.4647                        Prob > F           =    0.0000

------------------------------------------------------------------------------
          lq |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          lf |   -.286072   .1447074    -1.98   0.051    -.5728481     .000704
          lm |   1.229901   .1166257    10.55   0.000     .9987766    1.461026
          le |   .0667291   .1494044     0.45   0.656    -.2293554    .3628135
          ll |   .0708771   .1771064     0.40   0.690    -.2801063    .4218605
          lp |   .0329359   .0495029     0.67   0.507    -.0651673     .131039
       _cons |  -.1884351   .0316659    -5.95   0.000    -.2511894   -.1256808
-------------+----------------------------------------------------------------
     sigma_u |  .11865322
```

```
     sigma_e |  .11150891
         rho |  .53101049   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(9, 110) =     5.43                 Prob > F = 0.0000

. test lf+lm+le+ll+lp=1

 ( 1)  lf + lm + le + ll + lp = 1

       F(  1,   110) =    1.87
            Prob > F =    0.1742
```

■

Example 2: Stata data file `crime.dta` contains data for estimating the economic model of crime taken from Cornwall and Trumball (1994). The variables are the following:

- *county*: county identifier;
- *year*: years 1981 to 1987;
- *crmrte*: crimes committed per person;
- *prbarr*: probability of arrest;
- *prbconv*: probability of conviction;
- *prbpris*: probability of prison sentence;
- *avgsen*: average sentence, days;
- *polpc*: police per capita;
- *wcon*: weekly wage; construction;
- *wtuc*: weekly wage; transport, utilities and communications;
- *wtrd*: weekly wage; wholesale, retail trade;
- *wfir*: weekly wage; financial institutions, real estate;
- *wser*: weekly wage; service industry;
- *wmfg*: weekly wage; manufacturing;
- *wfed*: weekly wage; federal employees;
- *wsta*: weekly wage; state employees;
- *wloc*: weekly wage; local government employees.

Additionally, the data file already contains the year dummy variables (*d82*, ..., *d87*), the logs of variables (*lcrmrte*, ..., *lwloc*), and first differences in logs of some variables (*clcrmrte*, *clprbarr*, *clprbconv*, *clprbpris*, *clavgsen* and *clpolpc*).

a) Estimate a fixed effects model relating *lcrmrte* to *lprbarr*, *lprbconv*, *lprbpris*, *lavgsen* and *lpolpc*. Include also the year dummy variables.
b) Add the wage variables in logarithmic form, *lwcon* to *lwloc*, and test for joint significance of these added variables after estimation by the fixed effects estimator. What do you find?
c) Estimate the equation in part b) by the first-difference OLS estimator and comment on any notable changes in terms of the estimates of regression coefficients.
d) Estimate the model from part b) without the year dummy variables with the random effects estimator. Should you deal with the local (individual) effects in this case as fixed effects or random effects? Explain with reference to particular test statistic.
e) Finally, perform model diagnostics on the suggested model from part d) in terms of heteroscedasticity and first-order autocorrelation, and suggest solutions if necessary.

Computer printout of the results in Stata:

Exercise a)

```
. xtset county year
       panel variable:  county (strongly balanced)
        time variable:  year, 81 to 87
                delta:  1 unit

. xtdes

  county:  1, 3, ..., 197                                 n =         90
    year:  81, 82, ..., 87                                T =          7
           Delta(year) = 1 unit
           Span(year)  = 7 periods
           (county*year uniquely identifies each observation)

Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         7       7       7         7         7       7       7

     Freq.  Percent    Cum. |  Pattern
 ---------------------------+---------
       90    100.00  100.00 |  1111111
 ---------------------------+---------
       90    100.00         |  XXXXXXX

. xtsum crmrte-polpc

Variable         |      Mean   Std. Dev.       Min        Max |    Observations
-----------------+--------------------------------------------+----------------
crmrte   overall |  .0315876   .0181209   .0018116    .163835 |     N =     630
         between |             .0169893   .0039699   .0886855 |     n =      90
         within  |             .0065179  -.0112836   .1258057 |     T =       7
                 |                                           |
prbarr   overall |  .3073682   .1712047   .0588235       2.75 |     N =     630
         between |               .13578   .1142695     1.1489 |     n =      90
         within  |             .1051222  -.5290316   1.908468 |     T =       7
                 |                                           |
prbconv  overall |  .6886176   1.690345   .0683761         37 |     N =     630
         between |             .9267132   .2391829   8.315754 |     n =      90
         within  |             1.416566  -5.505927   29.37286 |     T =       7
                 |                                           |
prbpris  overall |  .4255184   .0872452    .148936    .678571 |     N =     630
         between |             .0530346   .2779191   .5611304 |     n =      90
         within  |             .0694686   .2057385   .6853913 |     T =       7
                 |                                           |
avgsen   overall |   8.95454   2.658082       4.22      25.83 |     N =     630
         between |             1.497908   6.277143   14.58143 |     n =      90
         within  |             2.200699   1.313111   20.20311 |     T =       7
                 |                                           |
polpc    overall |  .0019168   .0027349   .0004585   .0355781 |     N =     630
         between |             .0021545   .0006296   .0156888 |     n =      90
         within  |             .0016977  -.0128058   .0218061 |     T =       7

. xtreg lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc d82-d87, fe

Fixed-effects (within) regression               Number of obs      =       630
Group variable: county                          Number of groups   =        90

R-sq:  within  = 0.4342                         Obs per group: min =         7
       between = 0.4066                                        avg =       7.0
       overall = 0.4042                                        max =         7

                                                F(11,529)          =     36.91
corr(u_i, Xb)  = 0.2068                         Prob > F           =    0.0000
```

```
------------------------------------------------------------------------------
     lcrmrte |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lprbarr |  -.3597944   .0324192   -11.10   0.000    -.4234806   -.2961082
    lprbconv |  -.2858733   .0212173   -13.47   0.000    -.3275538   -.2441928
    lprbpris |  -.1827812   .0324611    -5.63   0.000    -.2465496   -.1190127
     lavgsen |  -.0044879   .0264471    -0.17   0.865    -.0564421    .0474663
      lpolpc |   .4241142   .0263661    16.09   0.000     .3723191    .4759093
          d82 |   .0125802   .0215416     0.58   0.559    -.0297373    .0548977
          d83 |  -.0792813   .0213399    -3.72   0.000    -.1212027   -.0373598
          d84 |  -.1177281   .0216145    -5.45   0.000    -.1601888   -.0752673
          d85 |  -.1119561   .0218459    -5.12   0.000    -.1548716   -.0690407
          d86 |  -.0818268   .0214266    -3.82   0.000    -.1239185   -.0397352
          d87 |  -.0404704   .0210392    -1.92   0.055    -.0818011    .0008602
        _cons |  -1.604135   .1685739    -9.52   0.000    -1.935292   -1.272979
-------------+----------------------------------------------------------------
     sigma_u |  .43487416
     sigma_e |  .13871215
         rho |  .90765322   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(89, 529) =    45.87             Prob > F = 0.0000
```

Exercise b)

. xtreg lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc d82-d87, fe

```
Fixed-effects (within) regression               Number of obs      =       630
Group variable: county                          Number of groups   =        90

R-sq:  within  = 0.4575                         Obs per group: min =         7
       between = 0.2518                                        avg =       7.0
       overall = 0.2687                                        max =         7

                                                F(20,520)          =     21.92
corr(u_i, Xb)  = 0.0804                         Prob > F           =    0.0000

------------------------------------------------------------------------------
     lcrmrte |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lprbarr |  -.3563515   .0321591   -11.08   0.000    -.4195292   -.2931738
    lprbconv |  -.2859539   .0210513   -13.58   0.000    -.3273099   -.2445979
    lprbpris |  -.1751355   .0323403    -5.42   0.000    -.2386693   -.1116017
     lavgsen |  -.0028739   .0262108    -0.11   0.913     -.054366    .0486181
      lpolpc |      .4229   .0263942    16.02   0.000     .3710476    .4747524
        lwcon |  -.0345448   .0391616    -0.88   0.378    -.1114792    .0423896
        lwtuc |   .0459747    .019034     2.42   0.016     .0085817    .0833677
        lwtrd |  -.0201766   .0406073    -0.50   0.619    -.0999511    .0595979
        lwfir |  -.0035445    .028333    -0.13   0.900    -.0592058    .0521168
        lwser |   .0101264   .0191915     0.53   0.598     -.027576    .0478289
        lwmfg |  -.3005691   .1094068    -2.75   0.006    -.5155028   -.0856354
        lwfed |  -.3331226    .176448    -1.89   0.060    -.6797612     .013516
        lwsta |   .0215209   .1130648     0.19   0.849    -.2005991    .2436409
        lwloc |   .1810215   .1180643     1.53   0.126    -.0509203    .4129632
          d82 |   .0188915   .0251244     0.75   0.452    -.0304662    .0682492
          d83 |   -.055286   .0330287    -1.67   0.095    -.1201721    .0096001
          d84 |  -.0615162   .0410805    -1.50   0.135    -.1422204    .0191879
          d85 |  -.0397115   .0561635    -0.71   0.480    -.1500468    .0706237
          d86 |  -.0001133   .0680124    -0.00   0.999    -.1337262    .1334996
          d87 |   .0537042   .0798953     0.67   0.502    -.1032532    .2106615
        _cons |   .8931726   1.424067     0.63   0.531     -1.90446    3.690805
-------------+----------------------------------------------------------------
     sigma_u |  .47756823
     sigma_e |  .13700505
```

```
         rho |  .92395784   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(89, 520) =    39.12             Prob > F = 0.0000
```

```
. testparm lwcon-lwloc

 ( 1)  lwcon = 0
 ( 2)  lwtuc = 0
 ( 3)  lwtrd = 0
 ( 4)  lwfir = 0
 ( 5)  lwser = 0
 ( 6)  lwmfg = 0
 ( 7)  lwfed = 0
 ( 8)  lwsta = 0
 ( 9)  lwloc = 0

       F(  9,   520) =    2.47
            Prob > F =    0.0090
```

Exercise c)

```
. sort county year

. by county: gen clwcon=d.lwcon
(90 missing values generated)

. by county: gen clwtuc=d.lwtuc
(90 missing values generated)

. by county: gen clwtrd=d.lwtrd
(90 missing values generated)

. by county: gen clwfir=d.lwfir
(90 missing values generated)

. by county: gen clwser=d.lwser
(90 missing values generated)

. by county: gen clwmfg=d.lwmfg
(90 missing values generated)

. by county: gen clwfed=d.lwfed
(90 missing values generated)

. by county: gen clwsta=d.lwsta
(90 missing values generated)

. by county: gen clwloc=d.lwloc
(90 missing values generated)

. reg clcrmrte clprbarr clprbconv clprbpris clavgsen clpolpc clwcon-clwloc d83-d87

      Source |       SS       df       MS              Number of obs =     540
-------------+------------------------------           F( 19,   520) =   21.90
       Model |  9.86742162    19   .51933798           Prob > F      =  0.0000
    Residual |  12.3293822   520   .02371035           R-squared     =  0.4445
-------------+------------------------------           Adj R-squared =  0.4242
       Total |  22.1968038   539  .041181454           Root MSE      =  .15398

------------------------------------------------------------------------------
    clcrmrte |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    clprbarr |  -.3230993   .0300195   -10.76   0.000    -.3820737   -.2641248
   clprbconv |  -.2402885   .0182474   -13.17   0.000    -.2761362   -.2044407
```

```
   clprbpris |  -.1693859     .02617    -6.47   0.000    -.2207978    -.117974
    clavgsen |  -.0156167   .0224126    -0.70   0.486    -.0596469    .0284136
     clpolpc |   .3977221    .026987    14.74   0.000     .3447051     .450739
      clwcon |  -.0442368   .0304142    -1.45   0.146    -.1039865     .015513
      clwtuc |   .0253997   .0142093     1.79   0.074     -.002515    .0533144
      clwtrd |  -.0290309   .0307907    -0.94   0.346    -.0895203    .0314586
      clwfir |    .009122   .0212318     0.43   0.668    -.0325886    .0508326
      clwser |   .0219549   .0144342     1.52   0.129    -.0064016    .0503113
      clwmfg |  -.1402482   .1019317    -1.38   0.169    -.3404967    .0600003
      clwfed |   .0174221   .1716065     0.10   0.919     -.319705    .3545493
      clwsta |  -.0517891   .0957109    -0.54   0.589    -.2398166    .1362385
      clwloc |  -.0305153   .1021028    -0.30   0.765       -.2311    .1700694
         d83 |  -.1108653   .0268105    -4.14   0.000    -.1635355   -.0581951
         d84 |  -.0374103    .024533    -1.52   0.128    -.0856063    .0107856
         d85 |  -.0005856    .024078    -0.02   0.981    -.0478877    .0467164
         d86 |   .0314757   .0245099     1.28   0.200    -.0166749    .0796262
         d87 |   .0388632   .0247819     1.57   0.117    -.0098218    .0875482
       _cons |   .0198522   .0206974     0.96   0.338    -.0208086     .060513
------------------------------------------------------------------------------
```

Exercise d)

. xtreg lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc, re

```
Random-effects GLS regression                   Number of obs      =       630
Group variable: county                          Number of groups   =        90

R-sq:  within  = 0.3928                         Obs per group: min =         7
       between = 0.4307                                        avg =       7.0
       overall = 0.4228                                        max =         7

                                                Wald chi2(14)      =    401.55
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
     lcrmrte |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lprbarr |  -.4613958     .03267   -14.12   0.000    -.5254279   -.3973637
    lprbconv |  -.3559061   .0214099   -16.62   0.000    -.3978688   -.3139434
    lprbpris |  -.1954779   .0350384    -5.58   0.000     -.264152   -.1268039
     lavgsen |   .0246275    .027457     0.90   0.370    -.0291872    .0784422
      lpolpc |   .4322999    .027269    15.85   0.000     .3788535    .4857462
       lwcon |   -.024313   .0422322    -0.58   0.565    -.1070866    .0584605
       lwtuc |   .0227724   .0193169     1.18   0.238    -.0150881    .0606329
       lwtrd |  -.0152788   .0447416    -0.34   0.733    -.1029707    .0724131
       lwfir |  -.0105347   .0312807    -0.34   0.736    -.0718438    .0507745
       lwser |  -.0037376    .021178    -0.18   0.860    -.0452458    .0377705
       lwmfg |  -.2574504   .0915891    -2.81   0.005    -.4369617   -.0779392
       lwfed |  -.0239489   .1556607    -0.15   0.878    -.3290382    .2811404
       lwsta |  -.0643574   .0950754    -0.68   0.498    -.2507017    .1219869
       lwloc |   .2014622   .1066653     1.89   0.059     -.007598    .4105224
       _cons |  -.8674546   .5899335    -1.47   0.141    -2.023703    .2887938
-------------+----------------------------------------------------------------
     sigma_u |  .28769553
     sigma_e |  .14068633
         rho |  .80701655   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

. qui xtreg lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc, fe
. estimates store fixed

. qui xtreg lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc, re
. estimates store random

. hausman fixed random

```
                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+------------------------------------------------------------
     lprbarr |   -.3859224    -.4613958        .0754734               .
    lprbconv |   -.3036125    -.3559061        .0522936               .
    lprbpris |   -.1919035    -.1954779        .0035744               .
     lavgsen |    .0240309     .0246275       -.0005966               .
      lpolpc |    .4300334     .4322999       -.0022664               .
       lwcon |   -.0330249     -.024313       -.0087119               .
       lwtuc |    .0287157     .0227724        .0059433               .
       lwtrd |   -.0393383    -.0152788       -.0240594               .
       lwfir |   -.0129124    -.0105347       -.0023778               .
       lwser |    .0040193    -.0037376         .007757               .
       lwmfg |   -.3577472    -.2574504       -.1002968        .0390327
       lwfed |   -.5765692    -.0239489       -.5526203        .0451007
       lwsta |    .1802285    -.0643574        .2445859        .0081476
       lwloc |    .3282651     .2014622         .126803               .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                 chi2(14) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      143.58
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Exercise e)

. qui xtreg lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc, fe
. xttest3

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (90)  =    4064.24
Prob>chi2 =      0.0000
```

. xtserial lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      89) =     24.389
           Prob > F =      0.0000
```

. xtregar lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc, fe

```
FE (within) regression with AR(1) disturbances  Number of obs     =        540
Group variable: county                          Number of groups  =         90

R-sq:                                           Obs per group:
     within  = 0.3989                                         min =          6
     between = 0.2915                                         avg =        6.0
     overall = 0.2988                                         max =          6

                                                F(14,436)         =      20.67
corr(u_i, Xb)  = 0.1479                         Prob > F          =     0.0000
```

```
------------------------------------------------------------------------------
     lcrmrte |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lprbarr |   -.342986   .0352361    -9.73   0.000    -.4122398   -.2737323
    lprbconv |  -.2634197   .0214244   -12.30   0.000    -.3055278   -.2213117
    lprbpris |  -.1697651   .0309125    -5.49   0.000    -.2305211   -.1090091
     lavgsen |  -.0371158   .0269405    -1.38   0.169    -.0900653    .0158336
      lpolpc |   .3797975   .0293039    12.96   0.000      .322203    .4373921
       lwcon |  -.0377715   .0359389    -1.05   0.294    -.1084065    .0328634
       lwtuc |    .024627   .0159391     1.55   0.123       -.0067    .0559539
       lwtrd |  -.0380998   .0366956    -1.04   0.300    -.1102221    .0340224
       lwfir |   .0048534   .0254641     0.19   0.849    -.0451943     .054901
       lwser |   .0109082   .0170627     0.64   0.523    -.0226272    .0444437
       lwmfg |  -.2872044   .1004502    -2.86   0.004    -.4846311   -.0897776
       lwfed |  -.2467577   .1868257    -1.32   0.187    -.6139486    .1204331
       lwsta |   .2030377   .0938255     2.16   0.031     .0186312    .3874441
       lwloc |   .2433557   .1000936     2.43   0.015     .0466297    .4400817
       _cons |  -1.084649   .5417221    -2.00   0.046    -2.149361   -.0199379
-------------+----------------------------------------------------------------
      rho_ar |  .35512642
     sigma_u |  .47520696
     sigma_e |   .1358762
     rho_fov |  .92442263   (fraction of variance because of u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(89,436) = 17.51                     Prob > F = 0.0000
```

. xtreg lcrmrte lprbarr lprbconv lprbpris lavgsen lpolpc lwcon-lwloc, fe vce(robust)

```
Fixed-effects (within) regression               Number of obs      =       630
Group variable: county                          Number of groups   =        90

R-sq:                                           Obs per group:
     within  = 0.4213                                         min =         7
     between = 0.1951                                         avg =       7.0
     overall = 0.2148                                         max =         7

                                                F(14,89)           =     11.05
corr(u_i, Xb)  = -0.0142                        Prob > F           =    0.0000

                                (Std. Err. adjusted for 90 clusters in county)
------------------------------------------------------------------------------
             |               Robust
     lcrmrte |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lprbarr |  -.3859224   .0602199    -6.41   0.000    -.5055781   -.2662668
    lprbconv |  -.3036125   .0492777    -6.16   0.000    -.4015262   -.2056988
    lprbpris |  -.1919035   .0447278    -4.29   0.000    -.2807767   -.1030302
     lavgsen |   .0240309   .0322307     0.75   0.458    -.0400108    .0880726
      lpolpc |   .4300334   .0761287     5.65   0.000     .2787673    .5812996
       lwcon |  -.0330249   .0272448    -1.21   0.229    -.0871598    .0211099
       lwtuc |   .0287157   .0153631     1.87   0.065    -.0018105    .0592418
       lwtrd |  -.0393383   .0299971    -1.31   0.193    -.0989418    .0202653
       lwfir |  -.0129124   .0149266    -0.87   0.389    -.0425713    .0167464
       lwser |   .0040193   .0199409     0.20   0.841    -.0356028    .0436415
       lwmfg |  -.3577472   .1095282    -3.27   0.002    -.5753773   -.1401171
       lwfed |  -.5765692   .2337947    -2.47   0.016    -1.041114   -.1120241
       lwsta |   .1802285   .0897132     2.01   0.048     .0019703    .3584868
       lwloc |   .3282651   .1426493     2.30   0.024     .0448241    .6117062
       _cons |   1.146124   .9728838     1.18   0.242    -.7869759    3.079223
-------------+----------------------------------------------------------------
     sigma_u |  .49341955
     sigma_e |  .14068633
         rho |  .92481584   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

■