Econometrics using STATA

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1

INTRODUCTION

1.1 AN OVERVIEW OF STATA'S DISTICTIVE FEATURES

- You can easily learn STATA commands, even if you do not know the syntex
- You can use STATA's do-file Editor to save time developing you analysis
- A simple command performs all computations for all the desired obervations
- Looping over variables saves time & effort
- STATA's by-groups reduce the need for programming
- STATA has many statistical features that make it uniquely powerful
- You can avoid problems by keeping STATA up to date
- STATA is infinitely extensible
- STATA's user community provides a wealth of useful additions to STATA
- STATA is cross-platform compatible
- STATA can be fun

2

WORKING WITH ECONOMIC AND FINANCIAL DATA IN STATA

2.1 THE BASICS

2.1.1 *The use Command*

```
. use census2c.(1980 Census data for NE and NC states)

. list, sep(0)
```

	state	region	pop	popurb	medage	marr	divr
1.	Connecticut	NE	3107.6	2449.8	32.00	26.0	13.5
2.	Illinois	N Cntrl	11426.5	9518.0	29.90	109.8	51.0
3.	Indiana	N Cntrl	5490.2	3525.3	29.20	57.9	40.0
4.	Iowa	N Cntrl	2913.8	1708.2	30.00	27.5	11.9
5.	Kansas	N Cntrl	2363.7	1575.9	30.10	24.8	13.4
6.	Maine	NE	1124.7	534.1	30.40	12.0	6.2
7.	Massachusetts	NE	5737.0	4808.3	31.20	46.3	17.9
8.	Michigan	N Cntrl	9262.1	6551.6	28.80	86.9	45.0
9.	Minnesota	N Cntrl	4076.0	2725.2	29.20	37.6	15.4
10.	Missouri	N Cntrl	4916.7	3349.6	30.90	54.6	27.6
11.	Nebraska	N Cntrl	1569.8	987.9	29.70	14.2	6.4
12.	New Hampshire	NE	920.6	480.3	30.10	9.3	5.3
13.	New Jersey	NE	7364.8	6557.4	32.20	55.8	27.8
14.	New York	NE	17558.1	14858.1	31.90	144.5	62.0
15.	N. Dakota	N Cntrl	652.7	318.3	28.30	6.1	2.1
16.	Ohio	N Cntrl	10797.6	7918.3	29.90	99.8	58.8
17.	Pennsylvania	NE	11863.9	8220.9	32.10	93.7	34.9
18.	Rhode Island	NE	947.2	824.0	31.80	7.5	3.6
19.	S. Dakota	N Cntrl	690.8	320.8	28.90	8.8	2.8
20.	Vermont	NE	511.5	172.7	29.40	5.2	2.6
21.	Wisconsin	N Cntrl	4705.8	3020.7	29.40	41.1	17.5

2.1.2 *Variable Types*

```
. use census2c.(1980 Census data for NE and NC states)

. describe

Contains data from census2c.dta
  obs:            21                          1980 Census data for NE and NC
                                                states
```

```
 vars:             7                          14 Jun 2006 08:48
 size:         1,050
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
state           str13   %-13s                 State
region          byte    %-8.0g     cenreg     Census region
pop             double  %8.1f                 1980 Population, '000
popurb          double  %8.1f                 1980 Urban population, '000
medage          float   %9.2f                 Median age, years
marr            double  %8.1f                 Marriages, '000
divr            double  %8.1f                 Divorces, '000
-------------------------------------------------------------------------------
Sorted by:
```

2.1.3 *Generate & Replace*

```
. use census2c.(1980 Census data for NE and NC states)

. generate urbanized = popurb/pop

. summarize urbanized

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
   urbanized |         21    .6667691    .1500842   .3377319   .8903645


. use census2c.(1980 Census data for NE and NC states)

. generate urbanized = popurb/pop

. replace urbanized = 100*urbanized
(21 real changes made)

. summarize urbanized

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
   urbanized |         21    66.67691    15.00843   33.77319   89.03645
```

2.1.4 *sort & gsort*

```
. use census2c.(1980 Census data for NE and NC states)

. list region state pop, sepby(region)

     +----------------------------------+
     | region    state              pop |
     |----------------------------------|
```

```
  1. | NE        Connecticut      3107.6 |
     |----------------------------------|
  2. | N Cntrl   Illinois        11426.5 |
  3. | N Cntrl   Indiana          5490.2 |
  4. | N Cntrl   Iowa             2913.8 |
  5. | N Cntrl   Kansas           2363.7 |
     |----------------------------------|
  6. | NE        Maine            1124.7 |
  7. | NE        Massachusetts    5737.0 |
     |----------------------------------|
  8. | N Cntrl   Michigan         9262.1 |
  9. | N Cntrl   Minnesota        4076.0 |
 10. | N Cntrl   Missouri         4916.7 |
 11. | N Cntrl   Nebraska         1569.8 |
     |----------------------------------|
 12. | NE        New Hampshire     920.6 |
 13. | NE        New Jersey       7364.8 |
 14. | NE        New York        17558.1 |
     |----------------------------------|
 15. | N Cntrl   N. Dakota         652.7 |
 16. | N Cntrl   Ohio            10797.6 |
     |----------------------------------|
 17. | NE        Pennsylvania    11863.9 |
 18. | NE        Rhode Island      947.2 |
     |----------------------------------|
 19. | N Cntrl   S. Dakota         690.8 |
     |----------------------------------|
 20. | NE        Vermont           511.5 |
     |----------------------------------|
 21. | N Cntrl   Wisconsin        4705.8 |
     +----------------------------------+

.
. sort region -pop

. list region state pop, sepby(region)

     +----------------------------------+
     | region    state               pop |
     |----------------------------------|
  1. | NE        Vermont           511.5 |
  2. | NE        New Hampshire     920.6 |
  3. | NE        Rhode Island      947.2 |
  4. | NE        Maine            1124.7 |
  5. | NE        Connecticut      3107.6 |
  6. | NE        Massachusetts    5737.0 |
  7. | NE        New Jersey       7364.8 |
  8. | NE        Pennsylvania    11863.9 |
  9. | NE        New York        17558.1 |
     |----------------------------------|
 10. | N Cntrl   N. Dakota         652.7 |
 11. | N Cntrl   S. Dakota         690.8 |
 12. | N Cntrl   Nebraska         1569.8 |
 13. | N Cntrl   Kansas           2363.7 |
 14. | N Cntrl   Iowa             2913.8 |
 15. | N Cntrl   Minnesota        4076.0 |
 16. | N Cntrl   Wisconsin        4705.8 |
```

```
 17. | N Cntrl   Missouri         4916.7 |
 18. | N Cntrl   Indiana          5490.2 |
 19. | N Cntrl   Michigan         9262.1 |
 20. | N Cntrl   Ohio            10797.6 |
 21. | N Cntrl   Illinois        11426.5 |
     +-----------------------------------+

.
. gsort region -pop

. list region state pop, sepby(region)

     +-----------------------------------+
     | region    state               pop |
     |-----------------------------------|
  1. | NE        New York        17558.1 |
  2. | NE        Pennsylvania    11863.9 |
  3. | NE        New Jersey       7364.8 |
  4. | NE        Massachusetts    5737.0 |
  5. | NE        Connecticut      3107.6 |
  6. | NE        Maine            1124.7 |
  7. | NE        Rhode Island      947.2 |
  8. | NE        New Hampshire     920.6 |
  9. | NE        Vermont           511.5 |
     |-----------------------------------|
 10. | N Cntrl   Illinois        11426.5 |
 11. | N Cntrl   Ohio            10797.6 |
 12. | N Cntrl   Michigan         9262.1 |
 13. | N Cntrl   Indiana          5490.2 |
 14. | N Cntrl   Missouri         4916.7 |
 15. | N Cntrl   Wisconsin        4705.8 |
 16. | N Cntrl   Minnesota        4076.0 |
 17. | N Cntrl   Iowa             2913.8 |
 18. | N Cntrl   Kansas           2363.7 |
 19. | N Cntrl   Nebraska         1569.8 |
 20. | N Cntrl   S. Dakota         690.8 |
 21. | N Cntrl   N. Dakota         652.7 |
     +-----------------------------------+
```

3

ORGANIZING & HANDLING ECONOMIC DATA

3.1 CROSS-SECTIONAL DATA & IDENTIFIER VARIABLES

3.2 TIME SERIES DATA

3.3 POOLED CROSS-SECTIONAL TIME SERIES DATA

3.4 PANEL DATA

3.5 TOOLS FOR MANIPULATING PANEL DATA

3.6 COMBINING CROSS-SECTIONAL & TIME SERIES DATASETS

3.7 CREATING LONG-FORMAT DATASETS WITH APPEND

3.8 THE RESHAPE COMMAND

3.9 USING STATA FOR REPRODUCIBLE RESEARCH

3.9.1 *Using do-files*

3.9.2 *Data Validation: Assert & Duplicates*

4

LINEAR REGRESSION

4.1 LINEAR REGRESSION

```
. use hprice2a.(Housing price data for Boston-area communities)

. summarize price lprice lnox ldist rooms stratio, sep(0)

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
       price |        506    22511.51    9208.856       5000      50001
      lprice |        506    9.941057     .409255   8.517193    10.8198
        lnox |        506    1.693091    .2014102   1.348073   2.164472
       ldist |        506    1.188233     .539501   .1222176   2.495682
       rooms |        506    6.284051    .7025938       3.56       8.78
     stratio |        506    18.45929     2.16582       12.6         22


. use hprice2a.(Housing price data for Boston-area communities)

. regress lprice lnox ldist rooms stratio

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(4, 501)       =    175.86
       Model |  49.3987735         4  12.3496934   Prob > F        =    0.0000
    Residual |  35.1834974       501  .070226542   R-squared       =    0.5840
-------------+----------------------------------   Adj R-squared   =    0.5807
       Total |  84.5822709       505  .167489645   Root MSE        =      .265

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |    -.95354   .1167418    -8.17   0.000    -1.182904   -.7241762
       ldist |  -.1343401   .0431032    -3.12   0.002    -.2190255   -.0496548
       rooms |   .2545271   .0185303    13.74   0.000     .2181203    .2909338
     stratio |  -.0524512   .0058971    -8.89   0.000    -.0640373   -.0408651
       _cons |   11.08387   .3181115    34.84   0.000     10.45887    11.70886
------------------------------------------------------------------------------
```

4.2 INFORMATION CRITERIA

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. estat ic
```

```
Akaike's information criterion and Bayesian information criterion

------------------------------------------------------------------------------
       Model |        Obs  ll(null)  ll(model)      df         AIC        BIC
-------------+----------------------------------------------------------------
           . |        506 -265.4135  -43.49514       5    96.99028    118.123
------------------------------------------------------------------------------
               Note: N=Obs used in calculating BIC; see [R] BIC note.
```

4.3 THE COEFFICIENT ESTIMATES & BETA COEFFICIENTS

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. regress, beta

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(4, 501)       =    175.86
       Model |  49.3987735         4  12.3496934   Prob > F        =    0.0000
    Residual |  35.1834974       501  .070226542   R-squared       =    0.5840
-------------+----------------------------------   Adj R-squared   =    0.5807
       Total |  84.5822709       505  .167489645   Root MSE        =      .265

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
        lnox |    -.95354   .1167418    -8.17   0.000               -.4692738
       ldist |  -.1343401   .0431032    -3.12   0.002               -.1770941
       rooms |   .2545271   .0185303    13.74   0.000                .4369626
     stratio |  -.0524512   .0058971    -8.89   0.000               -.2775771
       _cons |   11.08387   .3181115    34.84   0.000                       .
------------------------------------------------------------------------------
```

4.4 RECOVERING ESTIMATION RESULTS

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. ereturn list

scalars:
                  e(N) =  506
               e(df_m) =  4
               e(df_r) =  501
                  e(F) =  175.8550695227946
                 e(r2) =  .5840322442976398
               e(rmse) =  .2650029089298266
                e(mss) =  49.39877352102587
```

```
               e(rss) =  35.18349741237627
             e(r2_a) =  .5807111444517128
               e(ll) =  -43.4951392092929
             e(ll_0) =  -265.4134648194153
             e(rank) =  5

macros:
           e(cmdline) : "regress lprice lnox ldist rooms stratio"
             e(title) : "Linear regression"
          e(marginsok) : "XB default"
               e(vce) : "ols"
             e(depvar) : "lprice"
               e(cmd) : "regress"
         e(properties) : "b V"
            e(predict) : "regres_p"
              e(model) : "ols"
          e(estat_cmd) : "regress_estat"

matrices:
                 e(b) :  1 x 5
                 e(V) :  5 x 5

functions:
            e(sample)



. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. matrix list e(b)

e(b)[1,5]
          lnox       ldist       rooms     stratio       _cons
y1  -.95354002  -.13434015   .25452706  -.05245119   11.083865



. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. estat vce

Covariance matrix of coefficients of regress model

        e(V) |       lnox       ldist       rooms     stratio       _cons
-------------+------------------------------------------------------------
        lnox |  .01362865
       ldist |  .00426247   .00185789
       rooms |  .00035279   .00003043   .00034337
     stratio |  9.740e-07   .00002182   .00003374   .00003478
       _cons | -.03037429  -.01001835  -.00341397  -.00088151   .10119496
```

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
        lnox |      3.98    0.251533
       ldist |      3.89    0.257162
       rooms |      1.22    0.820417
     stratio |      1.17    0.852488
-------------+----------------------
    Mean VIF |      2.56
```

4.6 PRESENTING REGRESSION ESTIMATES

```
. use hprice2a.(Housing price data for Boston-area communities)

. generate rooms2 = rooms^2

.
. quietly regress lprice rooms

. estimates store model1

.
. quietly regress lprice rooms rooms2 ldist

. estimates store model2

.
. quietly regress lprice ldist stratio lnox

. estimates store model3

.
. quietly regress lprice lnox ldist rooms stratio

. estimates store model4

.
. estimates table model1 model2 model3 model4, stat(r2_a, rmse) b(%7.3g) se(%6.
> 3g) p(%4.3f)

----------------------------------------------------
    Variable | model1    model2    model3    model4
-------------+--------------------------------------
       rooms |    .369     -.821                .255
             |   .0201      .183               .0185
```

```
             |   0.000     0.000               0.000
      rooms2 |             .0889
             |              .014
             |             0.000
       ldist |              .237     -.157     -.134
             |             .0255     .0505     .0431
             |             0.000     0.002     0.002
     stratio |                      -.0775    -.0525
             |                       .0066     .0059
             |                       0.000     0.000
        lnox |                       -1.22     -.954
             |                        .135      .117
             |                       0.000     0.000
       _cons |    7.62      11.3      13.6      11.1
             |    .127      .584      .304      .318
             |   0.000     0.000     0.000     0.000
-------------+----------------------------------------
        r2_a |    .399        .5      .424      .581
        rmse |    .317      .289      .311      .265
------------------------------------------------------
                                     legend: b/se/p


. use hprice2a.(Housing price data for Boston-area communities)

. generate rooms2 = rooms^2

.
. quietly regress lprice rooms

. estimates store model1

.
. quietly regress lprice rooms rooms2 ldist

. estimates store model2

.
. quietly regress lprice ldist stratio lnox

. estimates store model3

.
. quietly regress lprice lnox ldist rooms stratio

. estimates store model4

.
. estimates table model1 model2 model3 model4, stat(r2_a rmse ll) b(%7.3g) star
>  title("Models of Median Housing Price")

Models of Median Housing Price

----------------------------------------------------------------------
    Variable |   model1       model2       model3       model4
-------------+--------------------------------------------------------
       rooms |    .369***     -.821***                   .255***
```

```
      rooms2 |                .0889***
       ldist |                 .237***     -.157**      -.134**
     stratio |                             -.0775***    -.0525***
        lnox |                             -1.22***     -.954***
       _cons |    7.62***      11.3***      13.6***      11.1***
-------------+----------------------------------------------------
        r2_a |    .399           .5         .424         .581
        rmse |    .317         .289         .311         .265
          ll |    -136        -88.6         -124        -43.5
------------------------------------------------------------------
                        legend: * p<0.05; ** p<0.01; *** p<0.001
```

4.7 HYPOTHESIS TESTS, LINEAR RESTRICTIONS, & CONSTRAINED LEAST SQUARES

4.7.1 *Wald Tests with Test*

```
. use hprice2a.(Housing price data for Boston-area communities)

. regress lprice lnox ldist rooms stratio

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(4, 501)       =    175.86
       Model |  49.3987735         4  12.3496934   Prob > F        =    0.0000
    Residual |  35.1834974       501  .070226542   R-squared       =    0.5840
-------------+----------------------------------   Adj R-squared   =    0.5807
       Total |  84.5822709       505  .167489645   Root MSE        =      .265

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |    -.95354   .1167418    -8.17   0.000    -1.182904   -.7241762
       ldist |  -.1343401   .0431032    -3.12   0.002    -.2190255   -.0496548
       rooms |   .2545271   .0185303    13.74   0.000     .2181203    .2909338
     stratio |  -.0524512   .0058971    -8.89   0.000    -.0640373   -.0408651
       _cons |   11.08387   .3181115    34.84   0.000     10.45887    11.70886
------------------------------------------------------------------------------

. test rooms

 ( 1)  rooms = 0

       F(  1,   501) =  188.67
            Prob > F =    0.0000



. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. test rooms = 0.33

 ( 1)  rooms = .33
```

```
       F(  1,   501) =   16.59
            Prob > F =    0.0001
```

4.7.2 *Wald Tests involving Linear Combinations of Parameters*

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. lincom rooms + ldist + stratio

 ( 1)  ldist + rooms + stratio = 0

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |   .0677357   .0490714     1.38   0.168    -.0286753    .1641468
------------------------------------------------------------------------------

. test ldist = stratio

 ( 1)  ldist - stratio = 0

       F(  1,   501) =    3.63
            Prob > F =    0.0574

. test lnox = 10*stratio

 ( 1)  lnox - 10*stratio = 0

       F(  1,   501) =   10.77
            Prob > F =    0.0011



. use hprice2a.(Housing price data for Boston-area communities)

. constraint def 1 rooms + ldist + stratio = 0

. cnsreg lprice lnox ldist rooms stratio, constraint(1)

Constrained linear regression                   Number of obs     =        506
                                                F(   3,    502)   =     233.42
                                                Prob > F          =     0.0000
                                                Root MSE          =     0.2652

 ( 1)  ldist + rooms + stratio = 0
------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |  -1.083392   .0691935   -15.66   0.000    -1.219337   -.9474478
       ldist |  -.1880712   .0185284   -10.15   0.000    -.2244739   -.1516684
       rooms |   .2430633     .01658    14.66   0.000     .2104886    .2756381
     stratio |  -.0549922   .0056075    -9.81   0.000    -.0660092   -.0439752
```

```
       _cons |   11.48651   .1270377    90.42   0.000     11.23691     11.7361
------------------------------------------------------------------------------
```

4.7.3 *Joint Hypothesis Tests*

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. test lnox ldist

 ( 1)  lnox = 0
 ( 2)  ldist = 0

       F(  2,   501) =   58.95
            Prob > F =    0.0000
```

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. test (lnox = 10*stratio) (ldist = stratio)

 ( 1)  lnox - 10*stratio = 0
 ( 2)  ldist - stratio = 0

       F(  2,   501) =    5.94
            Prob > F =    0.0028
```

4.7.4 *Testing Nonlinear Restrictions & Forming Nonlinear Combinations*

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. testnl _b[lnox] * _b[stratio] = 0.06

  (1)  _b[lnox] * _b[stratio] = 0.06

               chi2(1) =        1.44
           Prob > chi2 =        0.2300
```

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. testnl (_b[lnox] * _b[stratio] = 0.06) (_b[rooms] * _b[ldist] = 3 * _b[lnox])
>
```

```
  (1)  _b[lnox] * _b[stratio] = 0.06
  (2)  _b[rooms] * _b[ldist] = 3 * _b[lnox]

           chi2(2) =      184.94
         Prob > chi2 =        0.0000
```

4.7.5 *Testing Competing (Non-Nested) Models*

```
. use hprice2a.(Housing price data for Boston-area communities)

. nnest lprice lnox ldist rooms stratio (crime proptax ldist rooms stratio)
command nnest is unrecognized
r(199);

end of do-file
r(199);
```

4.8 COMPUTING RESIDUALS & PREDICTED VALUES

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. predict double lpricehat, xb

. label var lpricehat "Predicted log price"

. twoway (scatter lpricehat lprice, msize(small) mcolor(black) msize(tiny)) ||
> (line lprice lprice if lprice <., clwidth(thin)), ytitle("Predicted log media
> n housing price") xtitle("Actual log median housing price") aspectratio(1) le
> gend(off)
```

4.8.1 *Computing Interval Predictions*

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox if _n <= 100

. predict double xb if e(sample)
(option xb assumed; fitted values)
(406 missing values generated)

. predict double stdpred if e(sample), stdp
(406 missing values generated)

. scalar tval = invttail(e(df_r), 0.975)
```

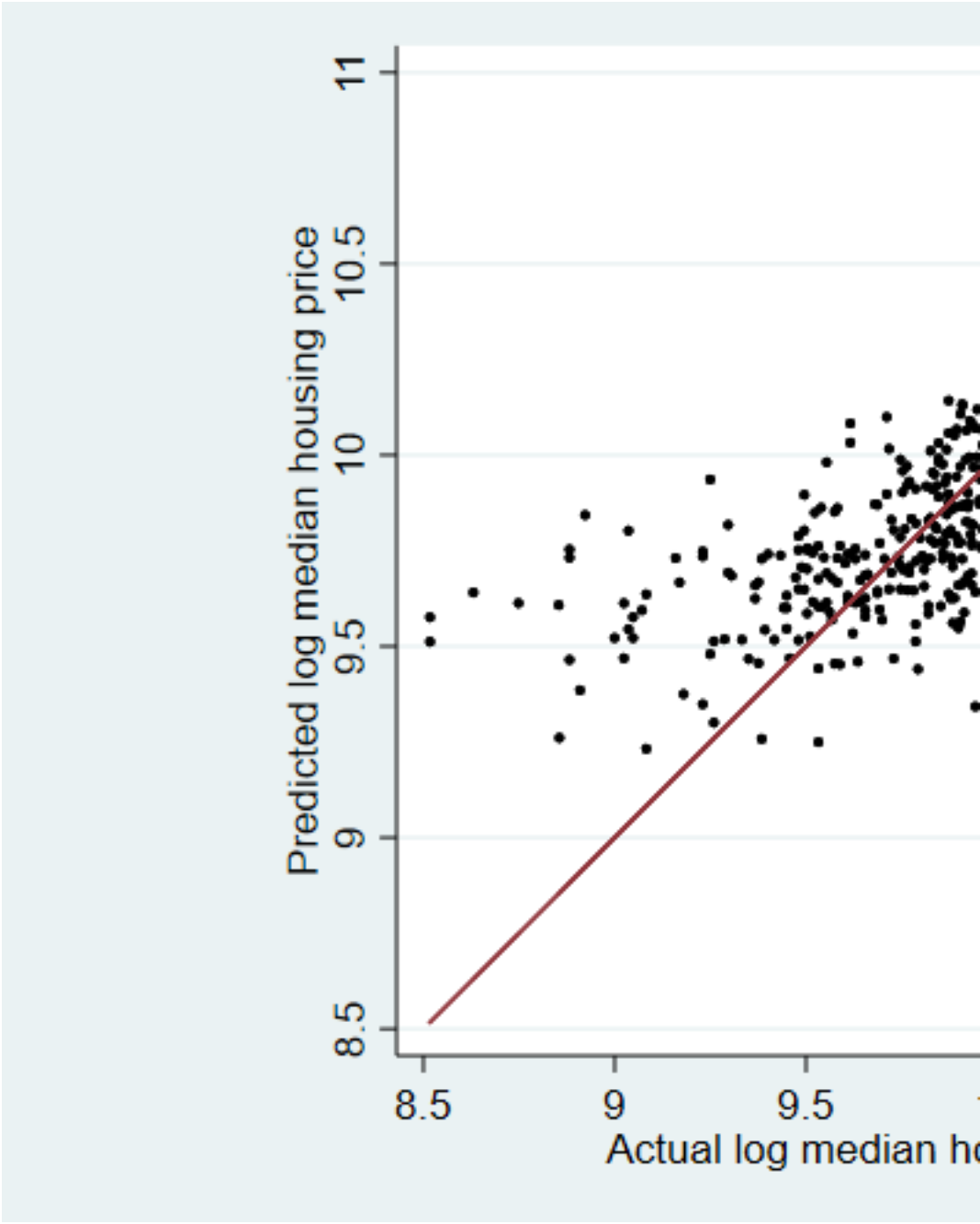

Figure 1: Actual versus predicted values from regression model

```
. generate double uplim = xb + tval * stdpred
(406 missing values generated)

. generate double lowlim = xb - tval * stdpred
(406 missing values generated)

.
. summarize lnox if e(sample), meanonly

. generate lnoxbar = r(mean)

.
. label var xb "Pred"

. label var uplim "95% prediction interval"

. label var lowlim "95% prediction interval"

.
. twoway (scatter lprice lnox if e(sample), sort ms(Oh) xline(‘lnoxbar’)) (conn
> ected xb lnox if e(sample), sort msize(small)) (rline uplim lowlim lnox if e(
> sample), sort), ytitle(Actual and predicted log price) legend(cols(3))

.
```

4.9 COMPUTING MARGINAL EFFECTS

```
. use hprice2a.(Housing price data for Boston-area communities)

. regress price nox dist rooms stratio proptax

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(5, 500)       =    165.85
       Model |  2.6717e+10         5  5.3434e+09   Prob > F        =    0.0000
    Residual |  1.6109e+10       500  32217368.7   R-squared       =    0.6239
-------------+----------------------------------   Adj R-squared   =    0.6201
       Total |  4.2826e+10       505    84803032   Root MSE        =      5676

------------------------------------------------------------------------------
       price |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         nox |  -2570.162    407.371    -6.31   0.000    -3370.532   -1769.793
        dist |  -955.7175   190.7124    -5.01   0.000    -1330.414    -581.021
       rooms |   6828.264   399.7034    17.08   0.000     6042.959    7613.569
     stratio |  -1127.534   140.7653    -8.01   0.000    -1404.099   -850.9699
     proptax |  -52.24272   22.53714    -2.32   0.021    -96.52188   -7.963555
       _cons |   20440.08   5290.616     3.86   0.000      10045.5    30834.66
------------------------------------------------------------------------------

. mfx, eyex

Elasticities after regress
      y  = Fitted values (predict)
```

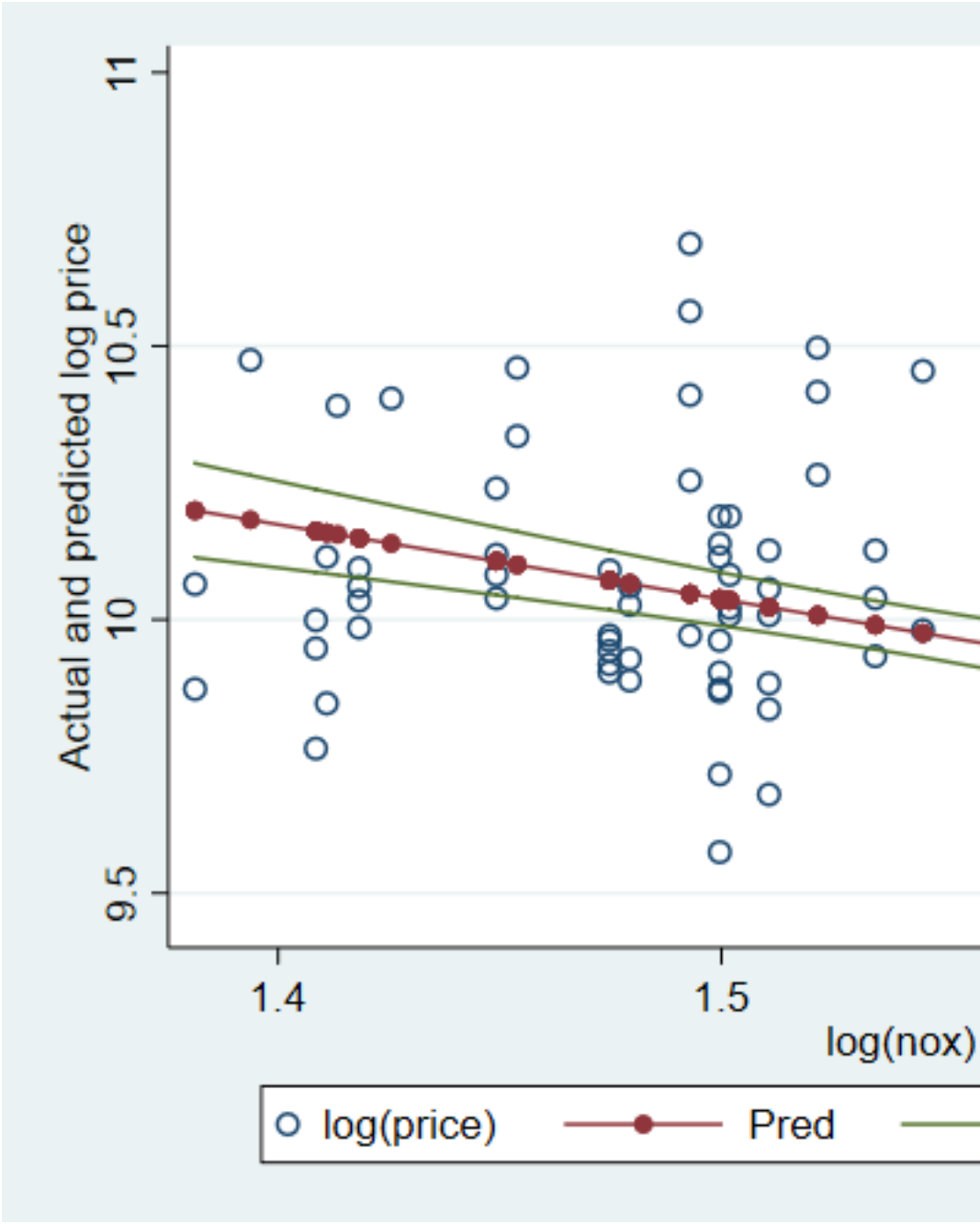

Figure 2: Point and interval predictions from bivariate regression

```
         =   22511.51
------------------------------------------------------------------------------
variable |      ey/ex    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     nox |  -.6336244      .10068   -6.29   0.000  -.830954 -.436295   5.54978
    dist |  -.1611472      .03221   -5.00   0.000  -.224273 -.098022   3.79575
   rooms |   1.906099       .1136   16.78   0.000   1.68344  2.12876   6.28405
 stratio |  -.9245706      .11589   -7.98   0.000  -1.15171 -.697429   18.4593
 proptax |  -.0947401      .04088   -2.32   0.020  -.174871 -.014609   40.8237
------------------------------------------------------------------------------
```

5

SPECIFYING THE FUNCTIONAL FORM

5.1 INTRODUCTION

5.2 SPECIFICATION ERROR

5.2.1 *Omitting relevant Variables from the Model*

5.2.2 *Graphically Analyzing Regression data*

```
. use hprice2a.(Housing price data for Boston-area communities)

. graph matrix lprice lnox ldist rooms stratio, ms(Oh) msize(tiny)
```

5.2.3 *Added-Variable Plots*

```
. use hprice2a.(Housing price data for Boston-area communities)

. generate rooms2 = rooms^2

. regress lprice lnox ldist rooms rooms2 stratio lproptax

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(6, 499)       =    138.41
       Model |  52.8357813         6  8.80596356   Prob > F        =    0.0000
    Residual |  31.7464896       499   .06362022   R-squared       =    0.6247
-------------+----------------------------------   Adj R-squared   =    0.6202
       Total |  84.5822709       505  .167489645   Root MSE        =    .25223

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |  -.6615694   .1201606    -5.51   0.000    -.8976524   -.4254864
       ldist |   -.095087   .0421435    -2.26   0.024    -.1778875   -.0122864
       rooms |  -.5625662   .1610315    -3.49   0.001    -.8789496   -.2461829
      rooms2 |   .0634347   .0124621     5.09   0.000     .0389501    .0879193
     stratio |  -.0362928   .0060699    -5.98   0.000    -.0482185   -.0243671
    lproptax |  -.2211125   .0410202    -5.39   0.000     -.301706   -.1405189
       _cons |   14.15454   .5693846    24.86   0.000     13.03585    15.27323
------------------------------------------------------------------------------

. avplots, ms(Oh) msize(small) col(2)
```

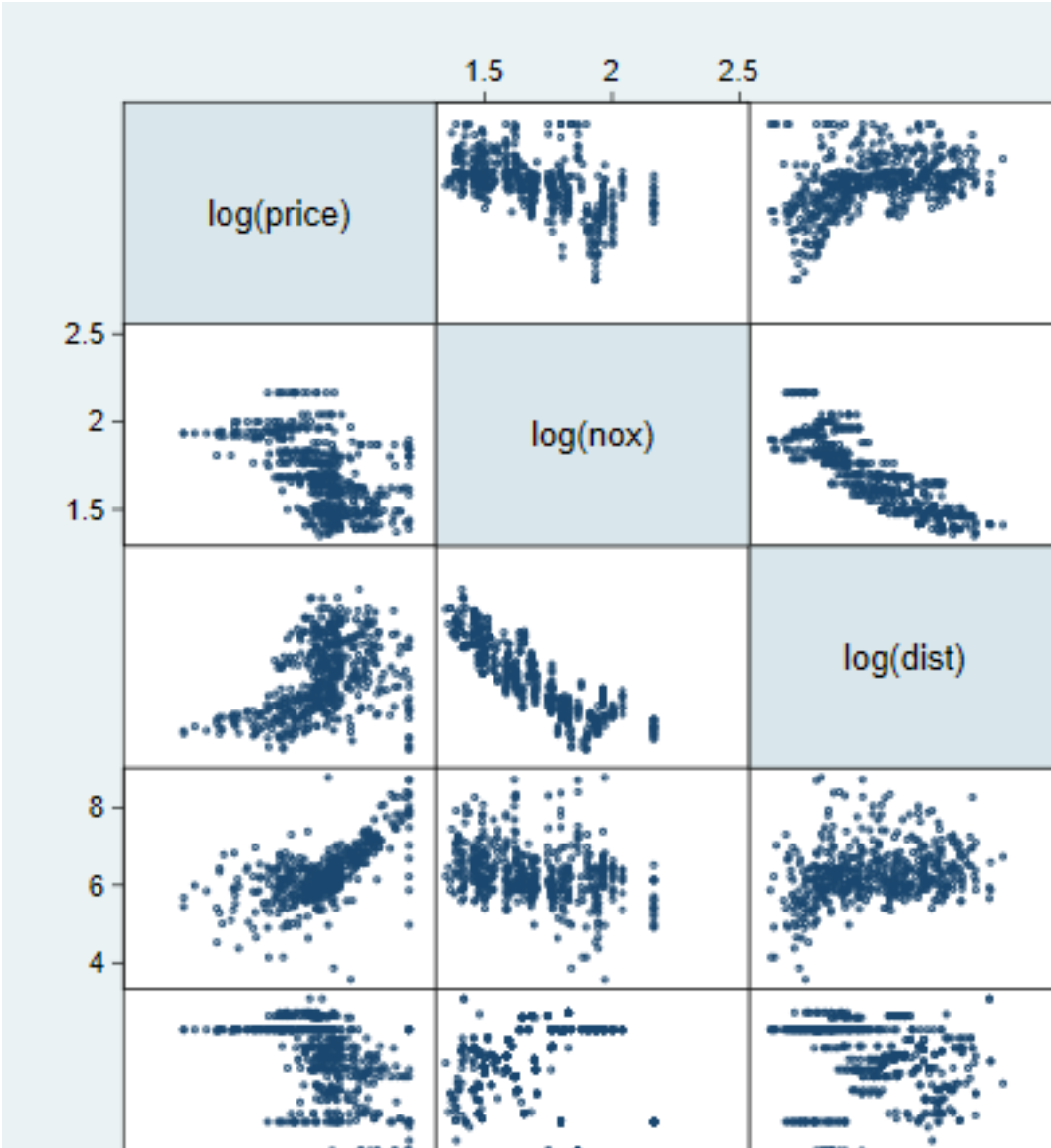

Figure 3: graph matrix of regression variables

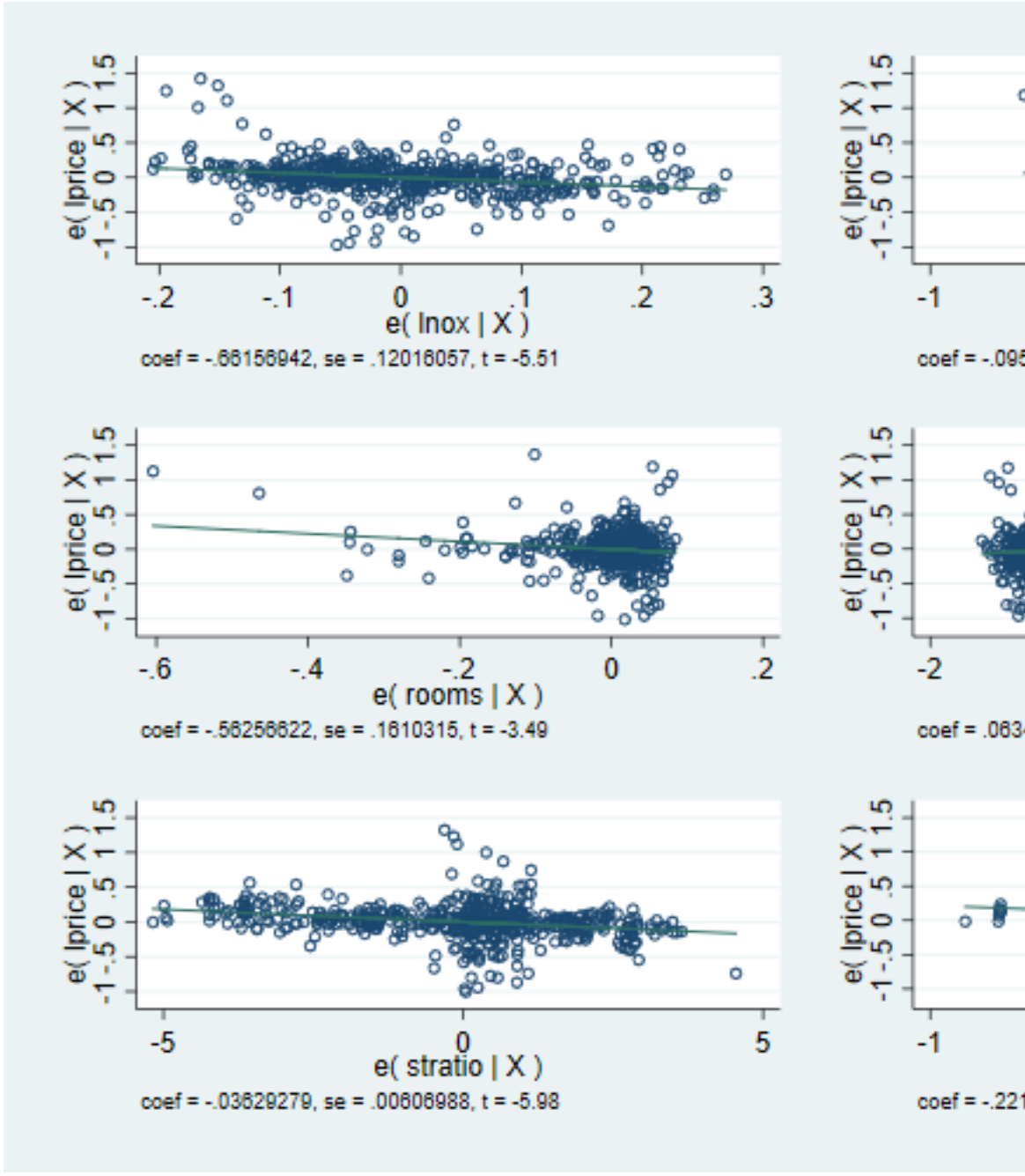

Figure 4: Added-variable plots

5.2.4 *Including Irrelevant Variables in the Model*

5.2.5 *The Asymmetry of Specification Error*

5.2.6 *Misspecification of the Functional Form*

5.2.7 *Ramsey's RESET*

```
. use hprice2a.(Housing price data for Boston-area communities)

. quietly regress lprice lnox ldist rooms stratio

. estat ovtest

Ramsey RESET test using powers of the fitted values of lprice
       Ho:  model has no omitted variables
                 F(3, 498) =      9.69
                  Prob > F =      0.0000

. estat ovtest, rhs

Ramsey RESET test using powers of the independent variables
       Ho:  model has no omitted variables
                 F(12, 489) =     11.79
                   Prob > F =      0.0000



. use hprice2a.(Housing price data for Boston-area communities)

. generate rooms2 = rooms^2

. regress lprice lnox ldist rooms rooms2 stratio lproptax

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(6, 499)       =    138.41
       Model |  52.8357813         6  8.80596356   Prob > F        =    0.0000
    Residual |  31.7464896       499   .06362022   R-squared       =    0.6247
-------------+----------------------------------   Adj R-squared   =    0.6202
       Total |  84.5822709       505  .167489645   Root MSE        =    .25223

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |  -.6615694   .1201606    -5.51   0.000    -.8976524   -.4254864
       ldist |   -.095087   .0421435    -2.26   0.024    -.1778875   -.0122864
       rooms |  -.5625662   .1610315    -3.49   0.001    -.8789496   -.2461829
      rooms2 |   .0634347   .0124621     5.09   0.000     .0389501    .0879193
     stratio |  -.0362928   .0060699    -5.98   0.000    -.0482185   -.0243671
    lproptax |  -.2211125   .0410202    -5.39   0.000     -.301706   -.1405189
       _cons |   14.15454   .5693846    24.86   0.000     13.03585    15.27323
------------------------------------------------------------------------------

. estat ovtest
```

```
Ramsey RESET test using powers of the fitted values of lprice
       Ho:  model has no omitted variables
                 F(3, 496) =      1.64
                  Prob > F =      0.1798
```

5.2.8 *Specification Plots*

```
. use hprice2a.(Housing price data for Boston-area communities)

. generate rooms2 = rooms^2

. quietly regress lprice lnox ldist rooms rooms2 stratio lproptax

. rvpplot ldist, ms(Oh) yline(0)
```

5.2.9 *Specification & Interaction Terms*

```
. use hprice2a.(Housing price data for Boston-area communities)

. generate taxschl = lproptax * stratio

. regress lprice lnox ldist lproptax stratio taxschl

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(5, 500)       =     84.47
       Model |  38.7301562         5  7.74603123   Prob > F        =    0.0000
    Residual |  45.8521148       500   .09170423   R-squared       =    0.4579
-------------+----------------------------------   Adj R-squared   =    0.4525
       Total |  84.5822709       505  .167489645   Root MSE        =    .30283

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnox |  -.9041103   .1441253    -6.27   0.000    -1.187276   -.6209444
       ldist |  -.1430541   .0501831    -2.85   0.005    -.2416499   -.0444583
    lproptax |   -1.48103   .5163117    -2.87   0.004    -2.495438   -.4666219
     stratio |  -.4388722   .1538321    -2.85   0.005    -.7411093   -.1366351
     taxschl |   .0641648    .026406     2.43   0.015     .0122843    .1160452
       _cons |   21.47905   2.952307     7.28   0.000      15.6786    27.27951
------------------------------------------------------------------------------
```

5.2.10 *Outlier Statistics & Measures of Leverage*

```
. use hprice2a.(Housing price data for Boston-area communities)

. generate rooms2 = rooms^2
```

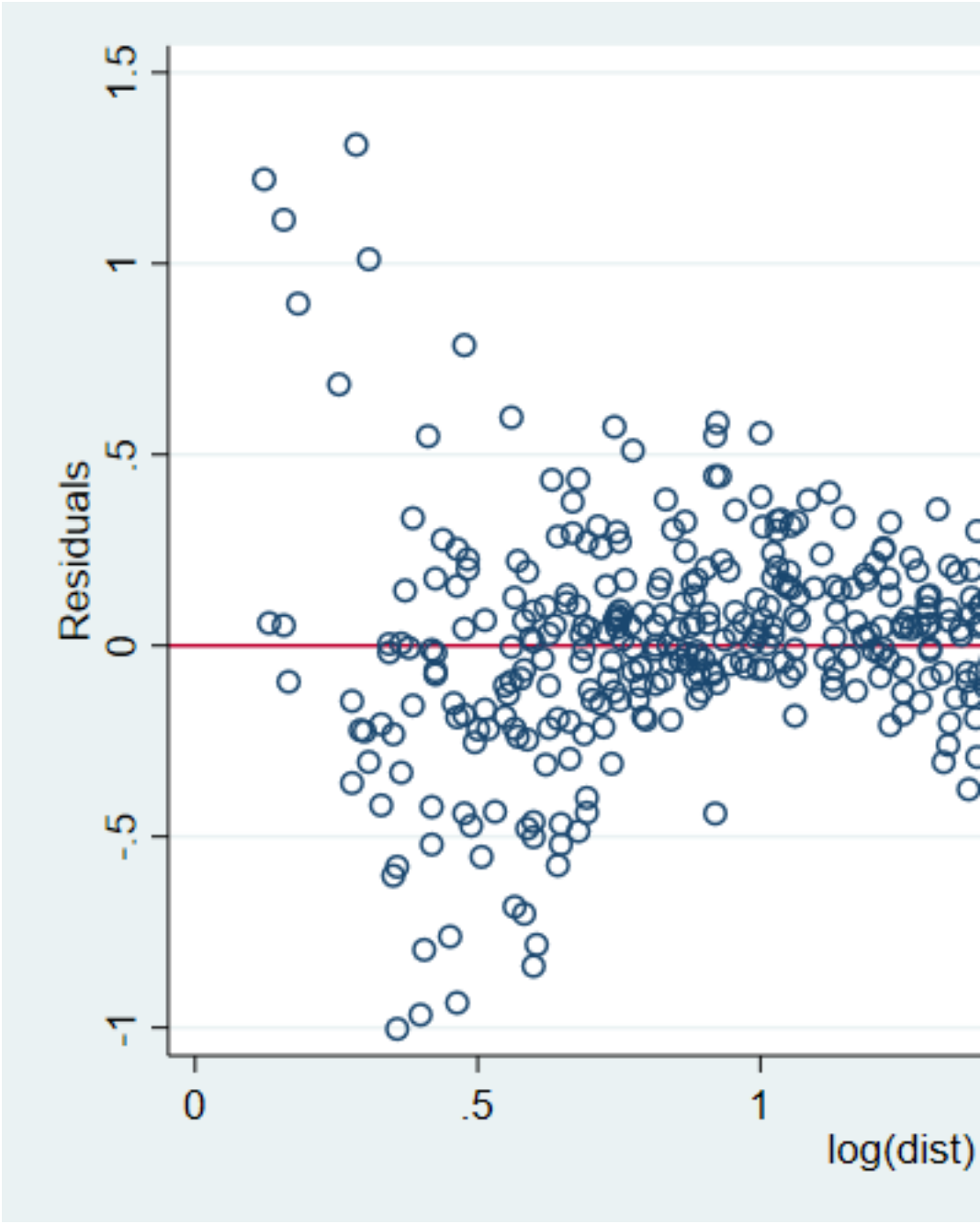

Figure 5: Residual-versus-predictor plot

```
. quietly regress lprice lnox ldist rooms rooms2 stratio lproptax

. generate town = _n

. predict double lev if e(sample), leverage

. predict double eps if e(sample), res

. generate eps2 = eps^2

. summarize price lprice

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
       price |        506    22511.51    9208.856       5000      50001
      lprice |        506    9.941057     .409255   8.517193    10.8198

. gsort -lev

. list town price lprice lev eps2 in 1/5

     +-------------------------------------------------+
     | town   price     lprice         lev       eps2 |
     |-------------------------------------------------|
  1. |  366   27499    10.2219   .17039262   .6181372 |
  2. |  368   23100   10.04759   .11272637   .3002205 |
  3. |  365   21900   9.994242   .10947853   .3308896 |
  4. |  258   50001    10.8198   .08036068   .0604706 |
  5. |  226   50001    10.8198    .0799096   .0338277 |
     +-------------------------------------------------+

. gsort -eps2

. list town price lprice lev eps2 in 1/5

     +-------------------------------------------------+
     | town   price     lprice         lev       eps2 |
     |-------------------------------------------------|
  1. |  369   50001    10.8198   .02250047    1.71812 |
  2. |  373   50001    10.8198   .01609848   1.489409 |
  3. |  372   50001    10.8198   .02056901   1.242105 |
  4. |  370   50001    10.8198    .0172083   1.022456 |
  5. |  406    5000   8.517193   .00854955   1.006366 |
     +-------------------------------------------------+

. predict double dfits if e(sample), dfits

. gsort -dfits

. quietly generate cutoff = abs(dfits) > 2 * sqrt((e(df_m) +1 )/e(N)) & e(sampl
> e)

. list town price lprice dfits if cutoff

     +-----------------------------------+
     | town   price     lprice        dfits |
```

```
     |-------------------------------------|
  1. |  366   27499    10.2219    1.5679033 |
  2. |  368   23100   10.04759    .82559867 |
  3. |  369   50001    10.8198     .8196735 |
  4. |  372   50001    10.8198    .65967704 |
  5. |  373   50001    10.8198    .63873964 |
     |-------------------------------------|
  6. |  371   50001    10.8198    .55639311 |
  7. |  370   50001    10.8198    .54354054 |
  8. |  361   24999   10.12659    .32184327 |
  9. |  359   22700   10.03012    .31516743 |
 10. |  408   27901   10.23642    .31281326 |
     |-------------------------------------|
 11. |  367   21900   9.994242    .31060611 |
 12. |  360   22600   10.02571    .28892457 |
 13. |  363   20800   9.942708    .27393758 |
 14. |  358   21700   9.985067    .24312885 |
490. |  386    7200   8.881836   -.23838749 |
     |-------------------------------------|
491. |  388    7400   8.909235   -.25909393 |
492. |  491    8100   8.999619   -.26584795 |
493. |  400    6300   8.748305   -.28782824 |
494. |  416    7200   8.881836   -.29288953 |
495. |  402    7200   8.881836   -.29595696 |
     |-------------------------------------|
496. |  381   10400   9.249561   -.29668364 |
497. |  258   50001    10.8198   -.30053391 |
498. |  385    8800   9.082507     -.302916 |
499. |  420    8400   9.035987   -.30843965 |
500. |  490    7000   8.853665    -.3142718 |
     |-------------------------------------|
501. |  401    5600   8.630522   -.33273658 |
502. |  417    7500   8.922658   -.34950136 |
503. |  399    5000   8.517193   -.36618139 |
504. |  406    5000   8.517193   -.37661853 |
505. |  415    7012   8.855378   -.43879798 |
     |-------------------------------------|
506. |  365   21900   9.994242   -.85150064 |
     +-------------------------------------+

. 
. dfbeta lnox
                      _dfbeta_1: dfbeta(lnox)

. quietly generate dfcut = abs(_dfbeta_1) > 2 * sqrt(e(N)) & e(sample)

. sort _dfbeta_1

. summarize lnox

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
        lnox |        506    1.693091    .2014102   1.348073   2.164472

. list town price lprice lnox _dfbeta_1

     +-----------------------------------------------+
```

	town	price	lprice	lnox	_dfbeta_1
1.	369	50001	10.8198	1.842136	-.4316933
2.	372	50001	10.8198	1.842136	-.4257791
3.	373	50001	10.8198	1.899118	-.3631822
4.	371	50001	10.8198	1.842136	-.2938702
5.	370	50001	10.8198	1.842136	-.2841335
6.	365	21900	9.994242	1.971299	-.2107066
7.	408	27901	10.23642	1.885553	-.1728729
8.	368	23100	10.04759	1.842136	-.1309522
9.	11	15000	9.615806	1.656321	-.1172723
10.	410	27499	10.2219	1.786747	-.1117743
11.	413	17900	9.792556	1.786747	-.0959273
12.	437	9600	9.169518	2.00148	-.0955826
13.	146	13800	9.532424	2.164472	-.0914387
14.	438	8700	9.071078	2.00148	-.0856147
15.	420	8400	9.035987	1.971299	-.085223
16.	145	11800	9.375854	2.164472	-.0816827
17.	439	8400	9.035987	2.00148	-.070508
18.	182	36199	10.49679	1.585145	-.0668001
19.	423	20800	9.942708	1.814825	-.064928
20.	157	13100	9.480368	2.164472	-.0622912
21.	258	50001	10.8198	1.867176	-.0570776
22.	158	41299	10.62859	1.800058	-.0563827
23.	409	17200	9.752665	1.786747	-.0549674
24.	343	16500	9.711116	1.644805	-.0542086
25.	414	16300	9.69892	1.786747	-.0522002
26.	143	13400	9.50301	2.164472	-.0499795
27.	446	11800	9.375854	2.00148	-.0498875
28.	31	12700	9.449357	1.682688	-.0480591
29.	156	15600	9.655026	2.164472	-.0474292
30.	493	20100	9.908475	1.806648	-.0472557
31.	480	21400	9.971147	1.814825	-.0469688
32.	481	23001	10.04329	1.671473	-.0465269
33.	451	13400	9.50301	1.964311	-.0461007
34.	9	16500	9.711116	1.656321	-.0449441
35.	33	13200	9.487972	1.682688	-.0427313
36.	28	14800	9.602383	1.682688	-.0383155
37.	32	14500	9.581903	1.682688	-.0374429
38.	188	32000	10.37349	1.474763	-.0370926
39.	435	11700	9.367344	1.964311	-.0370922
40.	454	17794	9.786616	1.964311	-.0369095
41.	436	13400	9.50301	2.00148	-.0368249
42.	35	13500	9.510445	1.682688	-.036522
43.	161	27000	10.20359	1.800058	-.035759
44.	441	10500	9.25913	2.00148	-.0354014
45.	26	13900	9.539644	1.682688	-.0336016
46.	445	10800	9.287301	2.00148	-.0330708

```
47. |   10   18900   9.846917   1.656321   -.0328998 |
48. |  101   27499    10.2219   1.648659   -.0317264 |
49. |  189   29801    10.3023   1.474763   -.0315825 |
50. |   12   18900   9.846917   1.656321   -.0311876 |
    |-----------------------------------------------|
51. |  472   19600   9.883285   1.671473   -.0303079 |
52. |  200   34899   10.46021   1.393766   -.0302973 |
53. |   34   13100   9.480368   1.682688   -.0300799 |
54. |  470   20100   9.908475   1.757858   -.0299316 |
55. |  482   23699   10.07319   1.671473   -.0295599 |
    |-----------------------------------------------|
56. |  162   50001    10.8198   1.800058   -.0294572 |
57. |  263   48801   10.79551   1.867176   -.0288593 |
58. |   23   15200    9.62905   1.682688   -.0284555 |
59. |  468   19100   9.857444   1.764731   -.0278265 |
60. |  448   12600   9.441452    2.00148    -.027274 |
    |-----------------------------------------------|
61. |  450   13000   9.472705   1.964311   -.0268602 |
62. |   24   14500   9.581903   1.682688   -.0267329 |
63. |  506   11900   9.384294   1.745715   -.0259339 |
64. |   75   24101   10.09001   1.474763   -.0255723 |
65. |  159   24299   10.09819   1.800058   -.0253549 |
    |-----------------------------------------------|
66. |  191   37001    10.5187   1.474763   -.0246281 |
67. |  106   19500    9.87817   1.648659   -.0242416 |
68. |  292   37298    10.5267   1.413423   -.0242084 |
69. |  107   19500    9.87817   1.648659   -.0240593 |
70. |  484   21800   9.989665   1.671473   -.0238902 |
    |-----------------------------------------------|
71. |   21   13600   9.517825   1.682688   -.0234366 |
72. |  230   31499   10.35771   1.617406   -.0231037 |
73. |  102   26500    10.1849   1.648659   -.0219822 |
74. |   62   16000   9.680344   1.510722   -.0219783 |
75. |  489   15200    9.62905   1.806648   -.0218215 |
    |-----------------------------------------------|
76. |   25   15600   9.655026   1.682688   -.0215176 |
77. |  127   15700   9.661416    1.83098   -.0211289 |
78. |  430    9500   9.159047   1.915451   -.0207799 |
79. |  455   14900   9.609117   1.964311   -.0206806 |
80. |  108   20400    9.92329   1.648659    -.020656 |
    |-----------------------------------------------|
81. |  173   23100   10.04759   1.629241    -.020537 |
82. |  215   23699   10.07319   1.587192   -.0205038 |
83. |  275   32400   10.38591   1.497388   -.0203821 |
84. |  184   32500     10.389   1.585145    -.019082 |
85. |  185   26399   10.18108   1.585145   -.0189528 |
    |-----------------------------------------------|
86. |  190   34899   10.46021   1.474763   -.0188717 |
87. |  456   14100    9.55393   1.964311   -.0187349 |
88. |  483   24999   10.12659   1.671473   -.0186684 |
89. |  473   23200   10.05191   1.757858   -.0183966 |
90. |  224   30101   10.31231   1.623341   -.0176759 |
    |-----------------------------------------------|
91. |  233   41702    10.6383   1.623341   -.0173393 |
92. |  180   37201   10.52409   1.585145   -.0173209 |
93. |  417    7500   8.922658   1.915451   -.0171022 |
94. |  375   13800   9.532424   1.899118   -.0166074 |
```

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 95. |  316   16200   9.692766   1.693779   -.0165045 |
     |-----------------------------------------------|
 96. |  279   29100   10.27849   1.497388   -.0162037 |
 97. |  119   20400    9.92329   1.699279   -.0161968 |
 98. |  176   29401   10.28878   1.629241   -.0161278 |
 99. |   29   18400   9.820106   1.682688   -.0157718 |
100. |  374   13800   9.532424   1.899118   -.0145677 |
     |-----------------------------------------------|
101. |  183   37900   10.54271   1.585145   -.0144407 |
102. |   40   30801    10.3353   1.453953    -.014429 |
103. |  495   24499   10.10639   1.766442   -.0138828 |
104. |  264   30999   10.34171   1.867176    -.013838 |
105. |  105   20100   9.908475   1.648659    -.013284 |
     |-----------------------------------------------|
106. |  457   12700   9.449357   1.964311   -.0129107 |
107. |  341   18700   9.836279   1.638997   -.0129061 |
108. |  193   36399    10.5023   1.474763   -.0128875 |
109. |   96   28399   10.25411   1.492904   -.0127983 |
110. |  201   32899    10.4012   1.393766   -.0126864 |
     |-----------------------------------------------|
111. |  192   30501   10.32551   1.474763   -.0125861 |
112. |  257   43998    10.6919   1.371181   -.0124312 |
113. |  276   32000   10.37349   1.497388   -.0120773 |
114. |  186   29599    10.2955   1.585145   -.0116235 |
115. |  338   18500   9.825526   1.638997   -.0116081 |
     |-----------------------------------------------|
116. |  494   21800   9.989665   1.766442   -.0114905 |
117. |  166   24999   10.12659   1.800058   -.0114317 |
118. |   99   43800   10.68739   1.492904   -.0108364 |
119. |   41   34899   10.46021   1.453953   -.0108243 |
120. |  471   19900   9.898475   1.757858   -.0104401 |
     |-----------------------------------------------|
121. |  278   33100   10.40729   1.497388   -.0101313 |
122. |   94   24999   10.12659   1.534714   -.0101088 |
123. |  111   21700   9.985067   1.699279     -.01002 |
124. |  317   17800   9.786954   1.693779   -.0099336 |
125. |  434   14300   9.568015   1.964311   -.0098488 |
     |-----------------------------------------------|
126. |  340   19000   9.852194   1.638997   -.0097685 |
127. |  117   21200   9.961757   1.699279   -.0093754 |
128. |  346   17500   9.769957    1.48614   -.0091785 |
129. |  469   17052   9.744022   1.757858   -.0091705 |
130. |  452   15200    9.62905   1.964311   -.0091184 |
     |-----------------------------------------------|
131. |  231   24299   10.09819   1.617406   -.0090826 |
132. |  268   50001    10.8198     1.7492    -.008913 |
133. |  179   29900   10.30561   1.629241   -.0087004 |
134. |  280   35102   10.46601     1.4884   -.0086304 |
135. |   68   22000   9.998797   1.408545   -.0085998 |
     |-----------------------------------------------|
136. |  347   17200   9.752665    1.48614   -.0085918 |
137. |   53   22620   10.02659   1.479329   -.0084467 |
138. |  429   11000   9.305651   1.915451   -.0083504 |
139. |  150   15400   9.642123   2.164472   -.0080456 |
140. |  349   24499   10.10639   1.470176   -.0077041 |
     |-----------------------------------------------|
141. |  213   22400   10.01682   1.587192   -.0074679 |
```

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142. |  163   50001    10.8198   1.800058   -.0072357 |
143. |  203   42302   10.65259   1.423108   -.0072147 |
144. |  214   28099   10.24349   1.587192   -.0071618 |
145. |  488   20600   9.933046   1.763017   -.0069738 |
     |-----------------------------------------------|
146. |  169   23799    10.0774   1.800058   -.0067039 |
147. |  168   23799    10.0774   1.800058   -.0066772 |
148. |  426    8300   9.024011   1.915451   -.0066314 |
149. |  393    9700   9.179881    1.94591   -.0066296 |
150. |   81   28001      10.24   1.449269   -.0064669 |
     |-----------------------------------------------|
151. |  140   17800   9.786954    1.83098   -.0063847 |
152. |   83   24800    10.1186   1.449269   -.0063639 |
153. |   52   20500    9.92818   1.479329   -.0061827 |
154. |  306   28399   10.25411   1.551809   -.0060002 |
155. |  104   19300   9.867861   1.648659   -.0059841 |
     |-----------------------------------------------|
156. |   51   19700   9.888374   1.479329   -.0058348 |
157. |  236   24000   10.08581   1.623341   -.0057875 |
158. |  499   21200   9.961757   1.766442   -.0056033 |
159. |    1   24000   10.08581   1.682688   -.0055244 |
160. |  254   42800   10.66429   1.460938   -.0054843 |
     |-----------------------------------------------|
161. |  165   22700   10.03012   1.800058   -.0053979 |
162. |  216   24999   10.12659   1.587192   -.0053433 |
163. |  416    7200   8.881836   1.915451   -.0053274 |
164. |  228   31600   10.36091   1.617406   -.0051245 |
165. |  293   27901   10.23642   1.413423   -.0049782 |
     |-----------------------------------------------|
166. |   27   16600   9.717158   1.682688   -.0049226 |
167. |   49   14400   9.574984   1.499623   -.0049053 |
168. |  229   46700    10.7515   1.617406   -.0047393 |
169. |  147   15600   9.655026   2.164472   -.0047173 |
170. |  175   22600   10.02571   1.629241   -.0047105 |
     |-----------------------------------------------|
171. |  128   16200   9.692766    1.83098   -.0045839 |
172. |  312   22099   10.00329   1.693779   -.0044402 |
173. |  122   20300   9.918376   1.759581   -.0044247 |
174. |  235   29001   10.27509   1.623341   -.0042688 |
175. |  274   35200    10.4688   1.534714   -.0042283 |
     |-----------------------------------------------|
176. |   73   22800   10.03452   1.418277   -.0041709 |
177. |  206   22600   10.02571   1.587192    -.004164 |
178. |  125   18800   9.841612   1.759581   -.0037207 |
179. |    2   21599   9.980402   1.545433   -.0036146 |
180. |  396   13100   9.480368    1.93586   -.0034284 |
     |-----------------------------------------------|
181. |   50   19400   9.873029   1.499623   -.0033576 |
182. |   39   24701    10.1146   1.607436   -.0031628 |
183. |  178   24600    10.1105   1.629241   -.0030147 |
184. |  110   19400   9.873029   1.648659   -.0029739 |
185. |   61   18700   9.836279   1.510722   -.0029386 |
     |-----------------------------------------------|
186. |  177   23200   10.05191   1.629241   -.0028818 |
187. |  210   20000   9.903487   1.587192   -.0027495 |
188. |  120   19300   9.867861   1.759581   -.0027346 |
189. |  124   17300   9.758462   1.759581   -.0025984 |
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190. |  148   14600   9.588777   2.164472   -.0025087 |
     |-----------------------------------------------|
191. |  123   20500    9.92818   1.759581   -.0022385 |
192. |  245   17600   9.775654   1.460938   -.0022249 |
193. |  167   50001    10.8198   1.800058    -.002166 |
194. |  500   17500   9.769957   1.766442   -.0021589 |
195. |  428   10900   9.296518   1.915451   -.0021474 |
     |-----------------------------------------------|
196. |  196   50001    10.8198   1.439835   -.0021369 |
197. |  248   20500    9.92818   1.460938    -.002122 |
198. |   18   17500   9.769957   1.682688   -.0020629 |
199. |   42   26601    10.1887   1.499623   -.0019077 |
200. |  342   32778   10.39751    1.48614   -.0018963 |
     |-----------------------------------------------|
201. |   48   16600   9.717158   1.499623   -.0018894 |
202. |   60   19600   9.883285   1.510722   -.0018844 |
203. |  226   50001    10.8198   1.617406    -.001832 |
204. |  155   17000   9.740969   2.164472   -.0018229 |
205. |  353   18600   9.830916   1.413423   -.0016996 |
     |-----------------------------------------------|
206. |  137   17400   9.764226    1.83098   -.0016503 |
207. |  394   13800   9.532424    1.93586   -.0016382 |
208. |  333   19400   9.873029   1.477049   -.0016011 |
209. |  211   21700   9.985067   1.587192   -.0015952 |
210. |  223   27499    10.2219   1.623341   -.0015933 |
     |-----------------------------------------------|
211. |  330   22600   10.02571   1.526056   -.0015749 |
212. |  220   23001   10.04329   1.704748   -.0015483 |
213. |  390   11500   9.350102    1.94591   -.0014979 |
214. |  272   25200    10.1346   1.534714   -.0014252 |
215. |  209   24399    10.1023   1.587192   -.0013174 |
     |-----------------------------------------------|
216. |  395   12700   9.449357    1.93586   -.0013078 |
217. |  505   22000   9.998797   1.745715   -.0012906 |
218. |  282   35401   10.47449     1.4884   -.0012697 |
219. |   63   22199    10.0078   1.510722   -.0011577 |
220. |  324   18500   9.825526   1.595339   -.0011329 |
     |-----------------------------------------------|
221. |  348   23100   10.04759   1.456287   -.0011269 |
222. |   74   23400   10.06049   1.418277   -.0010706 |
223. |  142   14400   9.574984    1.83098    -.001046 |
224. |   45   21200   9.961757   1.499623   -.0009506 |
225. |  296   28601    10.2612   1.474763   -.0009321 |
     |-----------------------------------------------|
226. |  129   18000   9.798127    1.83098   -.0008757 |
227. |  246   18500   9.825526   1.460938   -.0008337 |
228. |  309   22800   10.03452   1.693779   -.0007587 |
229. |  118   19200   9.862665   1.699279   -.0005592 |
230. |  112   22800   10.03452   1.699279    -.000556 |
     |-----------------------------------------------|
231. |  303   26399   10.18108   1.465567   -.0005297 |
232. |  335   20700   9.937889   1.638997   -.0004579 |
233. |   80   20300   9.918376   1.474763   -.0003887 |
234. |  208   22501   10.02131   1.587192     -.00029 |
235. |  126   21400   9.971147   1.759581   -.0002649 |
     |-----------------------------------------------|
236. |  504   23899   10.08159   1.745715   -.0001415 |
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237.	397	12500	9.433484	1.93586	-.0001163
238.	477	16700	9.723164	1.814825	-.000081
239.	86	26601	10.1887	1.501853	-.0000522
240.	232	31701	10.3641	1.617406	-.0000151
241.	310	20300	9.918376	1.693779	.0001054
242.	219	21500	9.975808	1.704748	.0001567
243.	283	46000	10.7364	1.4884	.0001949
244.	449	14100	9.55393	1.964311	.0002028
245.	277	33200	10.41031	1.497388	.0002292
246.	44	24701	10.1146	1.499623	.0002693
247.	305	36098	10.49399	1.551809	.000271
248.	344	23899	10.08159	1.576915	.0002758
249.	297	27100	10.20729	1.474763	.0003851
250.	84	22900	10.03889	1.449269	.0005833
251.	212	19300	9.867861	1.587192	.0005905
252.	43	25301	10.1386	1.499623	.0006433
253.	237	25099	10.13058	1.623341	.0006712
254.	37	20000	9.903487	1.607436	.0006828
255.	170	22299	10.0123	1.800058	.0007145
256.	130	14300	9.568015	1.83098	.0007622
257.	70	20900	9.947504	1.408545	.0008296
258.	207	24399	10.1023	1.587192	.000875
259.	251	24399	10.1023	1.460938	.00088
260.	314	21600	9.980449	1.693779	.0009465
261.	501	16800	9.729135	1.766442	.0010252
262.	238	31499	10.35771	1.623341	.0010367
263.	71	24200	10.09411	1.418277	.0010956
264.	57	24701	10.1146	1.410987	.0011089
265.	138	17100	9.746834	1.83098	.0011234
266.	252	24800	10.1186	1.460938	.0011321
267.	503	20600	9.933046	1.745715	.0011443
268.	323	20400	9.92329	1.595339	.0011816
269.	227	37602	10.53481	1.617406	.0013204
270.	30	21000	9.952278	1.682688	.0013535
271.	56	35401	10.47449	1.393766	.0014627
272.	440	12800	9.4572	2.00148	.0016096
273.	144	15600	9.655026	2.164472	.0016168
274.	313	19400	9.873029	1.693779	.0017158
275.	281	45401	10.72329	1.4884	.0017327
276.	217	23300	10.05621	1.704748	.0018928
277.	136	18100	9.803667	1.83098	.0019621
278.	15	18200	9.809176	1.682688	.0020112
279.	271	21100	9.957028	1.534714	.0020471
280.	172	19100	9.857444	1.800058	.0023016
281.	267	30699	10.33199	1.867176	.0023292
282.	113	18800	9.841612	1.699279	.0023302
283.	87	22501	10.02131	1.501853	.0023375
284.	475	13800	9.532424	1.764731	.0023762

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285. |  352   24101   10.09001   1.413423     .002526 |
     |-----------------------------------------------|
286. |  244   23699   10.07319   1.453953    .0025868 |
287. |   85   23899   10.08159   1.501853    .0026809 |
288. |   72   21700   9.985067   1.418277    .0027141 |
289. |  225   44802   10.71001   1.617406    .0027266 |
290. |  304   33100   10.40729   1.551809    .0027396 |
     |-----------------------------------------------|
291. |   90   28701   10.26469   1.587192    .0029018 |
292. |  403   12100   9.400961    1.93586    .0029982 |
293. |  135   15600   9.655026    1.83098    .0030177 |
294. |  337   19500    9.87817   1.638997    .0030569 |
295. |  384   12300   9.417355    1.94591    .0031938 |
     |-----------------------------------------------|
296. |   38   13668   9.522813   1.607436    .0032047 |
297. |  266   22800   10.03452   1.867176    .0032496 |
298. |  187   50001    10.8198   1.585145    .0033213 |
299. |  291   28501   10.25769   1.413423    .0033408 |
300. |  422   14200   9.560997   1.971299    .0033722 |
     |-----------------------------------------------|
301. |  351   22900   10.03889   1.456287    .0033961 |
302. |  131   19200   9.862665    1.83098      .00347 |
303. |  322   23100   10.04759   1.595339     .003478 |
304. |  249   24499   10.10639   1.460938    .0034818 |
305. |  204   48499    10.7893   1.425515    .0035265 |
     |-----------------------------------------------|
306. |  164   50001    10.8198   1.800058    .0035734 |
307. |   13   21700   9.985067   1.656321    .0036516 |
308. |  474   29801    10.3023   1.814825    .0039417 |
309. |  250   26200   10.17351   1.460938    .0039509 |
310. |  181   39799    10.5916   1.585145    .0041167 |
     |-----------------------------------------------|
311. |   79   21200   9.961757   1.474763    .0041254 |
312. |  498   18300   9.814656   1.766442    .0041364 |
313. |  502   22400   10.01682   1.745715    .0042514 |
314. |  339   20548   9.930519   1.638997    .0043115 |
315. |  234   48301   10.78521   1.623341    .0043629 |
     |-----------------------------------------------|
316. |  308   28201   10.24711   1.551809     .004465 |
317. |  354   30101   10.31231   1.410987    .0044676 |
318. |  321   23799    10.0774   1.595339    .0046011 |
319. |  383   11300   9.332558    1.94591    .0047599 |
320. |  389   10200   9.230143    1.94591    .0047679 |
     |-----------------------------------------------|
321. |  194   31101     10.345   1.388791    .0047706 |
322. |  260   30101   10.31231   1.867176    .0047774 |
323. |  294   23899   10.08159   1.474763    .0049389 |
324. |  222   21700   9.985067   1.623341    .0049435 |
325. |  121   22000   9.998797   1.759581    .0049438 |
     |-----------------------------------------------|
326. |  243   22199    10.0078   1.453953    .0050146 |
327. |  171   17400   9.764226   1.800058    .0053822 |
328. |  315   23799    10.0774   1.693779    .0055875 |
329. |  259   36001    10.4913   1.867176    .0056653 |
330. |  273   24399    10.1023   1.534714    .0056988 |
     |-----------------------------------------------|
331. |  331   19800   9.893437   1.526056    .0057538 |
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332. |  109   19800   9.893437   1.648659     .005793 |
333. |  404    8300   9.024011    1.93586    .0060482 |
334. |  319   23100   10.04759   1.693779     .006068 |
335. |  444   15400   9.642123    2.00148    .0062065 |
     |-----------------------------------------------|
336. |  114   18700   9.836279   1.699279    .0064821 |
337. |   47   20000   9.903487   1.499623    .0065764 |
338. |  350   26601    10.1887   1.456287    .0065786 |
339. |    3   34700    10.4545   1.545433     .006829 |
340. |  195   29100   10.27849   1.388791    .0068445 |
     |-----------------------------------------------|
341. |  411   15000   9.615806   1.786747    .0069358 |
342. |  247   24299   10.09819   1.460938    .0069601 |
343. |  497   19700   9.888374   1.766442    .0070464 |
344. |  355   18200   9.809176   1.418277    .0070865 |
345. |  320   21000   9.952278   1.693779    .0070909 |
     |-----------------------------------------------|
346. |  307   33400   10.41631   1.551809     .007096 |
347. |  479   14600   9.588777   1.814825    .0070969 |
348. |   36   18900   9.846917   1.607436    .0071105 |
349. |  261   33799   10.42819   1.867176    .0072586 |
350. |  116   18300   9.814656   1.699279    .0072618 |
     |-----------------------------------------------|
351. |   20   18200   9.809176   1.682688    .0075003 |
352. |  285   32199   10.37969   1.386294     .007564 |
353. |  318   19800   9.893437   1.693779    .0076158 |
354. |  329   19300   9.867861   1.526056    .0076533 |
355. |   64   24999   10.12659   1.510722    .0076632 |
     |-----------------------------------------------|
356. |   46   19300   9.867861   1.499623    .0077691 |
357. |  415    7012   8.855378    1.93586     .007824 |
358. |  419    8800   9.082507   1.915451     .007874 |
359. |  458   13500   9.510445   1.964311    .0080279 |
360. |  205   50001    10.8198   1.425515    .0081019 |
     |-----------------------------------------------|
361. |  447   14900   9.609117    2.00148    .0081669 |
362. |  298   20300   9.918376   1.474763    .0085907 |
363. |   76   21400   9.971147   1.474763    .0091335 |
364. |   82   23899   10.08159   1.449269    .0092037 |
365. |  287   20100   9.908475   1.348073    .0093339 |
     |-----------------------------------------------|
366. |  270   20700   9.937889   1.534714    .0094668 |
367. |  391   15100    9.62245    1.94591    .0096289 |
368. |  387   10500    9.25913    1.94591    .0096712 |
369. |  332   17100   9.746834   1.477049     .009686 |
370. |  461   16400   9.705036   1.964311    .0097336 |
     |-----------------------------------------------|
371. |  103   18600   9.830916   1.648659    .0097767 |
372. |    7   22900   10.03889   1.656321    .0099829 |
373. |  255   21900   9.994242   1.366092    .0101005 |
374. |  239   23699   10.07319   1.453953    .0102395 |
375. |  132   19600   9.883285    1.83098    .0102551 |
     |-----------------------------------------------|
376. |  288   23200   10.05191   1.398717    .0103194 |
377. |  284   50001    10.8198   1.388791    .0103747 |
378. |  487   19100   9.857444   1.763017    .0104986 |
379. |  311   16100   9.686575   1.693779    .0105595 |
```

```
380. |  325   24999   10.12659   1.595339    .0105819 |
     |-----------------------------------------------|
381. |  433   16100   9.686575   1.764731    .0107606 |
382. |  256   20900   9.947504   1.366092    .0108386 |
383. |  290   24800    10.1186   1.398717    .0114381 |
384. |  174   23600     10.069   1.629241    .0116044 |
385. |  496   23100   10.04759   1.766442    .0117644 |
     |-----------------------------------------------|
386. |   65   33001   10.40429   1.425515    .0121224 |
387. |   78   20800   9.942708   1.474763    .0121406 |
388. |  265   36501   10.50509   1.867176    .0122671 |
389. |  421   16700   9.723164   1.971299    .0123169 |
390. |  218   28701   10.26469   1.704748     .012537 |
     |-----------------------------------------------|
391. |   54   23400   10.06049   1.479329    .0129076 |
392. |   55   18900   9.846917   1.410987    .0129513 |
393. |  221   26699   10.19238   1.623341    .0129747 |
394. |  327   23001   10.04329   1.595339    .0132197 |
395. |  100   33200   10.41031   1.492904      .01351 |
     |-----------------------------------------------|
396. |   58   32562    10.3909   1.413423    .0140252 |
397. |  202   24101   10.09001   1.423108    .0143737 |
398. |  240   23300   10.05621   1.453953    .0146344 |
399. |   93   22900   10.03889   1.534714    .0146731 |
400. |   88   22199    10.0078   1.501853    .0147033 |
     |-----------------------------------------------|
401. |  328   22199    10.0078   1.595339    .0147417 |
402. |  295   21700   9.985067   1.474763    .0149248 |
403. |   91   22600   10.02571   1.587192    .0149329 |
404. |  418   10400   9.249561   1.915451    .0149713 |
405. |  459   14900   9.609117   1.964311    .0150557 |
     |-----------------------------------------------|
406. |   22   19600   9.883285   1.682688    .0152086 |
407. |  398    8500   9.047821    1.93586    .0153095 |
408. |  269   43499   10.68049     1.7492    .0162008 |
409. |  478   12000   9.392662   1.814825    .0163773 |
410. |  300   29001   10.27509   1.386294    .0168745 |
     |-----------------------------------------------|
411. |  139   13300    9.49552    1.83098    .0171233 |
412. |   89   23600     10.069   1.587192    .0173629 |
413. |  242   20100   9.908475   1.453953    .0176759 |
414. |  289   22299    10.0123   1.398717    .0176951 |
415. |  356   20600   9.933046   1.418277    .0178045 |
     |-----------------------------------------------|
416. |  253   29599    10.2955   1.460938    .0179755 |
417. |    6   28701   10.26469   1.521699    .0180267 |
418. |  405    8500   9.047821    1.93586    .0180952 |
419. |  199   34600   10.45161   1.396245    .0184836 |
420. |   92   22000   9.998797   1.587192    .0186358 |
     |-----------------------------------------------|
421. |  326   24600    10.1105   1.595339    .0192508 |
422. |  134   18400   9.820106    1.83098    .0196824 |
423. |  241   22000   9.998797   1.453953    .0201607 |
424. |  153   15300   9.635608   2.164472    .0202187 |
425. |    4   33400   10.41631   1.521699    .0206138 |
     |-----------------------------------------------|
426. |  424   13400    9.50301   1.814825    .0206475 |
```

```
427. |  141   14000   9.546813    1.83098    .0206522 |
428. |   59   23300   10.05621   1.510722    .0209189 |
429. |  385    8800   9.082507    1.94591    .0216851 |
430. |  485   20600   9.933046   1.763017    .0229157 |
     |-----------------------------------------------|
431. |  492   13600   9.517825   1.806648    .0231727 |
432. |  115   18500   9.825526   1.699279    .0234778 |
433. |   19   20200   9.913438   1.682688    .0239359 |
434. |  336   21100   9.957028   1.638997    .0240607 |
435. |   66   23501    10.0648   1.381282    .0240661 |
     |-----------------------------------------------|
436. |  412   17200   9.752665   1.786747    .0244541 |
437. |  133   23001   10.04329    1.83098    .0251679 |
438. |  453   16100   9.686575   1.964311    .0252416 |
439. |  197   33300   10.41331   1.396245    .0256373 |
440. |  334   22199    10.0078   1.638997    .0258975 |
     |-----------------------------------------------|
441. |  388    7400   8.909235    1.94591    .0263166 |
442. |   69   17400   9.764226   1.408545    .0263849 |
443. |    5   36199   10.49679   1.521699    .0266658 |
444. |   95   20600   9.933046   1.534714    .0274035 |
445. |  407   11900   9.384294   1.885553    .0274155 |
     |-----------------------------------------------|
446. |  402    7200   8.881836    1.93586    .0280494 |
447. |  299   22501   10.02131   1.386294    .0307287 |
448. |   98   38700   10.56359   1.492904    .0308795 |
449. |   16   19900   9.898475   1.682688    .0313705 |
450. |  345   31201   10.34821   1.576915    .0318101 |
     |-----------------------------------------------|
451. |  262   43101    10.6713   1.867176     .032273 |
452. |  379   13100   9.480368   1.903599    .0328231 |
453. |  198   30300    10.3189   1.396245    .0330362 |
454. |  486   21200   9.961757   1.763017    .0337355 |
455. |  302   22000   9.998797   1.465567    .0341089 |
     |-----------------------------------------------|
456. |  431   14500   9.581903   1.764731    .0342425 |
457. |  301   24800    10.1186   1.386294    .0343599 |
458. |   77   20000   9.903487   1.474763    .0356156 |
459. |   97   21400   9.971147   1.492904    .0357894 |
460. |  476   13300    9.49552   1.764731    .0361187 |
     |-----------------------------------------------|
461. |  442   17100   9.746834    2.00148    .0364184 |
462. |   14   20400    9.92329   1.682688    .0369498 |
463. |  377   13900   9.539644   1.903599    .0369729 |
464. |  401    5600   8.630522    1.93586    .0383786 |
465. |  367   21900   9.994242   1.971299    .0430825 |
     |-----------------------------------------------|
466. |    8   27100   10.20729   1.656321     .043922 |
467. |  382   10900   9.296518   1.903599    .0451832 |
468. |  378   13300    9.49552   1.903599    .0464509 |
469. |  467   19000   9.852194   1.879465    .0484201 |
470. |  386    7200   8.881836    1.94591     .048621 |
     |-----------------------------------------------|
471. |  376   15000   9.615806   1.903599    .0488837 |
472. |   67   19400   9.873029   1.381282    .0490895 |
473. |  425   11700   9.367344   1.764731    .0514093 |
474. |  462   17700    9.78132   1.964311    .0535513 |
```

```
475. |  443   18400   9.820106    2.00148    .0566888 |
     |-----------------------------------------------|
476. |  286   22000   9.998797   1.358409    .0573509 |
477. |   17   23100   10.04759   1.682688    .0589057 |
478. |  400    6300   8.748305    1.93586    .0589789 |
479. |  432   14100    9.55393   1.764731    .0600489 |
480. |  465   21400   9.971147   1.879465    .0677176 |
     |-----------------------------------------------|
481. |  380   10200   9.230143   1.903599    .0691514 |
482. |  364   16800   9.729135    2.04122    .0709101 |
483. |  392   23200   10.05191    1.94591    .0715526 |
484. |  381   10400   9.249561   1.903599    .0725951 |
485. |  149   17794   9.786616   2.164472    .0743867 |
     |-----------------------------------------------|
486. |  466   19900   9.898475   1.879465    .0744588 |
487. |  399    5000   8.517193    1.93586    .0797595 |
488. |  366   27499    10.2219   1.971299    .0797842 |
489. |  357   17794   9.786616    2.04122    .0857706 |
490. |  154   19400   9.873029   2.164472    .0910494 |
     |-----------------------------------------------|
491. |  463   19500    9.87817   1.964311    .0941472 |
492. |  464   20200   9.913438   1.964311    .0974507 |
493. |  427   10200   9.230143   1.764731    .1007114 |
494. |  406    5000   8.517193    1.93586    .1024767 |
495. |  151   21500   9.975808   2.164472    .1047597 |
     |-----------------------------------------------|
496. |  152   19600   9.883285   2.164472    .1120427 |
497. |  460   20000   9.903487   1.964311    .1142668 |
498. |  160   23300   10.05621   2.164472    .1165014 |
499. |  491    8100   8.999619   1.806648    .1222368 |
500. |  362   19900   9.898475    2.04122    .1376445 |
     |-----------------------------------------------|
501. |  363   20800   9.942708    2.04122    .1707894 |
502. |  490    7000   8.853665   1.806648    .1791869 |
503. |  358   21700   9.985067    2.04122    .1827834 |
504. |  360   22600   10.02571    2.04122    .2209745 |
505. |  361   24999   10.12659    2.04122    .2422512 |
     |-----------------------------------------------|
506. |  359   22700   10.03012    2.04122    .2483543 |
     +-----------------------------------------------+
```

5.3 ENDOGENEITY & MEASUREMENT ERROR

6

REGRESSION WITH NON-IID ERRORS

6.1 THE GENERALIZED LINEAR REGRESSION MODEL

6.1.1 *Types of Deviations from i.i.d. Errors*

6.1.2 *The Robust Estimator of VCE*

```
. use fertil2.. describe

Contains data from fertil2.dta
  obs:         4,361
 vars:            30                          2 Dec 2004 00:16
 size:       484,071
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
mnthborn        float   %9.0g
yearborn        float   %9.0g
age             float   %9.0g
electric        float   %9.0g
radio           float   %9.0g
tv              float   %9.0g
bicycle         float   %9.0g
educ            float   %9.0g
ceb             float   %9.0g
agefbrth        float   %9.0g
children        float   %9.0g
knowmeth        float   %9.0g
usemeth         float   %9.0g
monthfm         float   %9.0g
yearfm          float   %9.0g
agefm           float   %9.0g
idlnchld        float   %9.0g
heduc           float   %9.0g
agesq           float   %9.0g
urban           float   %9.0g
urbeduc         float   %9.0g
spirit          float   %9.0g
protest         float   %9.0g
catholic        float   %9.0g
frsthalf        float   %9.0g
educ0           float   %9.0g
evermarr        float   %9.0g
_est_OLS        byte    %8.0g                 esample() from estimates store
_est_robust     byte    %8.0g                 esample() from estimates store
_est_cluster    byte    %8.0g                 esample() from estimates store
-------------------------------------------------------------------------------
```

Sorted by:

```
. summarize
```

Variable	Obs	Mean	Std. Dev.	Min	Max
mnthborn	4,361	6.331346	3.323333	1	12
yearborn	4,361	60.43362	8.682723	38	73
age	4,361	27.40518	8.685233	15	49
electric	4,358	.1402019	.3472363	0	1
radio	4,359	.7017665	.457535	0	1
tv	4,359	.0929112	.2903413	0	1
bicycle	4,358	.2758146	.4469751	0	1
educ	4,361	5.855996	3.927075	0	20
ceb	4,361	2.441642	2.406861	0	13
agefbrth	3,273	19.0113	3.092333	10	38
children	4,361	2.267828	2.222032	0	13
knowmeth	4,354	.9632522	.1881636	0	1
usemeth	4,290	.5776224	.4939956	0	1
monthfm	2,079	6.270322	3.619943	1	12
yearfm	2,079	76.91246	7.760183	50	88
agefm	2,079	20.68639	5.002383	10	46
idlnchld	4,241	4.615892	2.219303	0	20
heduc	1,956	5.144683	4.803028	0	20
agesq	4,361	826.46	526.9232	225	2401
urban	4,361	.5166246	.4997808	0	1
urbeduc	4,361	3.469158	4.294228	0	20
spirit	4,361	.4221509	.493959	0	1
protest	4,361	.2277001	.4193961	0	1
catholic	4,361	.1024994	.3033387	0	1
frsthalf	4,361	.5404724	.4984164	0	1
educ0	4,361	.2077505	.4057437	0	1
evermarr	4,361	.4767255	.4995153	0	1
_est_OLS	4,361	.7367576	.4404433	0	1
_est_robust	4,361	.7367576	.4404433	0	1
_est_cluster	4,361	.7367576	.4404433	0	1

```
. use fertil2.. regress ceb age agefbrth usemeth
```

Source	SS	df	MS	Number of obs	=	3,213
				F(3, 3209)	=	1433.16
Model	9202.53439	3	3067.51146	Prob > F	=	0.0000
Residual	6868.49331	3,209	2.14038433	R-squared	=	0.5726
				Adj R-squared	=	0.5722
Total	16071.0277	3,212	5.00343328	Root MSE	=	1.463

ceb	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	.2237368	.003448	64.89	0.000	.2169763	.2304974
agefbrth	-.2606634	.0087954	-29.64	0.000	-.2779085	-.2434184

```
     usemeth |   .1873702   .0554298     3.38   0.001     .0786888    .2960516
       _cons |   1.358134   .1737828     7.82   0.000     1.017397     1.69887
------------------------------------------------------------------------------

. estimates store nonRobust

. summarize ceb age agefbrth usemeth children if e(sample)

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
         ceb |      3,213    3.230003    2.236836          1         13
         age |      3,213    29.93931    7.920432         15         49
    agefbrth |      3,213    19.00498    3.098121         10         38
     usemeth |      3,213    .6791161    .4668889          0          1
    children |      3,213    2.999378    2.055579          0         13

. regress ceb age agefbrth usemeth, robust

Linear regression                               Number of obs     =      3,213
                                                F(3, 3209)        =     874.06
                                                Prob > F          =     0.0000
                                                R-squared         =     0.5726
                                                Root MSE          =      1.463

------------------------------------------------------------------------------
             |               Robust
         ceb |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .2237368   .0046619    47.99   0.000     .2145962    .2328775
    agefbrth |  -.2606634   .0095616   -27.26   0.000    -.2794109   -.2419159
     usemeth |   .1873702   .0606446     3.09   0.002     .0684642    .3062762
       _cons |   1.358134   .1675624     8.11   0.000     1.029593    1.686674
------------------------------------------------------------------------------

. estimates store Robust

. estimates table nonRobust Robust, b(%9.4f) se(%5.3f) t(%5.2f) p(%4.3f) title(
> Estimates of CEB with OLS and Robust Standard Errors)

Estimates of CEB with OLS and Robust Standard Errors

-------------------------------------
    Variable | nonRobust    Robust
-------------+-----------------------
         age |    0.2237      0.2237
             |     0.003       0.005
             |     64.89       47.99
             |     0.000       0.000
    agefbrth |   -0.2607     -0.2607
             |     0.009       0.010
             |    -29.64      -27.26
             |     0.000       0.000
     usemeth |    0.1874      0.1874
             |     0.055       0.061
             |      3.38        3.09
             |     0.001       0.002
       _cons |    1.3581      1.3581
```

```
             |     0.174       0.168
             |      7.82        8.11
             |     0.000       0.000
-------------------------------------
                      legend: b/se/t/p
```

6.1.3 *The Cluster Estimator of VCE*

```
. use fertil2.. regress ceb age agefbrth usemeth, cluster(children)

Linear regression                               Number of obs     =      3,213
                                                F(3, 13)          =      20.91
                                                Prob > F          =     0.0000
                                                R-squared         =     0.5726
                                                Root MSE          =      1.463

                              (Std. Err. adjusted for 14 clusters in children)
------------------------------------------------------------------------------
             |               Robust
         ceb |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .2237368   .0315086     7.10   0.000     .1556665    .2918071
    agefbrth |  -.2606634   .0354296    -7.36   0.000    -.3372045   -.1841224
     usemeth |   .1873702   .0943553     1.99   0.069     -.016472    .3912125
       _cons |   1.358134   .4248589     3.20   0.007     .4402818    2.275985
------------------------------------------------------------------------------
```

6.1.4 *The Newey–West Estimator of VCE*

```
. use ukrates.. describe

Contains data from ukrates.dta
  obs:           526
 vars:             3                          2 Dec 2004 10:43
 size:         6,312
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
rs              float   %9.0g
month           float   %tm
r20             float   %9.0g
-------------------------------------------------------------------------------
Sorted by: month

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
          rs |        526    7.651513    3.553109   1.561667      16.18
       month |        526       168.5    151.9874        -94        431
```

```
         r20 |        526    8.863726    3.224372       3.35      17.18

. quietly regress D.rs LD.r20

. estimates store nonHAC

. newey D.rs LD.r20, lag(5)

Regression with Newey-West standard errors      Number of obs     =        524
maximum lag: 5                                  F(  1,       522) =      36.00
                                                Prob > F          =     0.0000

------------------------------------------------------------------------------
             |             Newey-West
        D.rs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         r20 |
         LD. |   .4882883   .0813867     6.00   0.000     .3284026     .648174
             |
       _cons |   .0040183   .0254102     0.16   0.874    -.0459004    .0539371
------------------------------------------------------------------------------

. estimates store NeweyWest

. estimates table nonHAC NeweyWest, b(%9.4f) se(%5.3f) t(%5.2f) p(%4.3f) title(
> Estimates of D.rs with OLS and Newey-West Standard Errors)

Estimates of D.rs with OLS and Newey-West Standard Errors

-------------------------------------
    Variable |  nonHAC     NeweyWest
-------------+-----------------------
         r20 |
         LD. |    0.4883      0.4883
             |     0.067       0.081
             |      7.27        6.00
             |     0.000       0.000
             |
       _cons |    0.0040      0.0040
             |     0.022       0.025
             |      0.18        0.16
             |     0.858       0.874
-------------------------------------
                      legend: b/se/t/p
```

6.1.5 *The Generalized Least Squares Estimator*

6.2 HETEROSKEDASTICITY IN THE ERROR DISTRIBUTION

6.2.1 *Heteroskedasticity Related to Scale*

6.2.1.1 *Testing for Heteroskedasticity Related to Scale*

```
. use hprice2a.(Housing price data for Boston-area communities)

. regress lprice rooms crime ldist

      Source |       SS           df       MS      Number of obs   =       506
-------------+----------------------------------   F(3, 502)       =    219.03
       Model |  47.9496883         3  15.9832294   Prob > F        =    0.0000
    Residual |  36.6325827       502  .072973272   R-squared       =    0.5669
-------------+----------------------------------   Adj R-squared   =    0.5643
       Total |  84.5822709       505  .167489645   Root MSE        =    .27014

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       rooms |   .3072343   .0178231    17.24   0.000     .2722172    .3422514
       crime |  -.0174486    .001591   -10.97   0.000    -.0205744   -.0143228
       ldist |    .074858   .0255746     2.93   0.004     .0246115    .1251045
       _cons |   7.984449   .1128067    70.78   0.000     7.762817     8.20608
------------------------------------------------------------------------------

. estat hettest, iid

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lprice

         chi2(1)      =    44.67
         Prob > chi2  =   0.0000

. estat hettest rooms crime ldist, iid

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: rooms crime ldist

         chi2(3)      =    80.11
         Prob > chi2  =   0.0000

. whitetst
command whitetst is unrecognized
r(199);

end of do-file
r(199);
```

6.2.1.2 *Feasible Generalized Least Squares Estimation*

```
. use hprice2a.(Housing price data for Boston-area communities)

. generate rooms2 = rooms^2

. regress lprice rooms crime ldist [aw=1/rooms2]
(sum of wgt is 13.31716591697057)

      Source |       SS           df       MS      Number of obs   =       506
```

```
-------------+----------------------------------   F(3, 502)       =    159.98
       Model |  39.6051883         3  13.2017294   Prob > F        =    0.0000
    Residual |   41.426616       502  .082523139   R-squared       =    0.4888
-------------+----------------------------------   Adj R-squared   =    0.4857
       Total |  81.0318042       505  .160459018   Root MSE        =    .28727

------------------------------------------------------------------------------
      lprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       rooms |   .2345368   .0194432    12.06   0.000     .1963367     .272737
       crime |  -.0175759   .0016248   -10.82   0.000    -.0207682   -.0143837
       ldist |   .0650916    .027514     2.37   0.018     .0110349    .1191483
       _cons |   8.450081   .1172977    72.04   0.000     8.219626    8.680536
------------------------------------------------------------------------------
```

6.2.2 *Heteroskedasticity Between Groups of Observations*

6.2.2.1 *Testing for Heteroskedasticity Between Groups of Observations*

```
. use NEdata.. describe

Contains data from NEdata.dta
  obs:           120
 vars:             6                          24 Oct 2004 13:28
 size:         2,640
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
state           long    %8.0g      state
year            int     %8.0g
pop             float   %9.0g
dpi             float   %9.0g
dpipc           float   %9.0g
ldpipc          float   %9.0g
-------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
       state |        120         3.5    1.714986          1          6
        year |        120      1990.5    5.790459       1981       2000
         pop |        120     2196276     1931629     515594    6362076
         dpi |        120    4.33e+07    4.46e+07    4385134   1.93e+08
       dpipc |        120    18.15802    5.662848   8.153382   33.38758
-------------+--------------------------------------------------------
      ldpipc |        120    2.848302    .3265395   2.098433   3.508184

. regress dpipc year

      Source |       SS           df       MS      Number of obs   =       120
-------------+----------------------------------   F(1, 118)       =    440.17
```

```
       Model |  3009.33617         1  3009.33617   Prob > F        =    0.0000
    Residual |  806.737449       118  6.83675804   R-squared       =    0.7886
-------------+----------------------------------   Adj R-squared   =    0.7868
       Total |  3816.07362       119  32.0678456   Root MSE        =    2.6147

------------------------------------------------------------------------------
       dpipc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .8684582   .0413941    20.98   0.000     .7864865    .9504298
       _cons |  -1710.508   82.39534   -20.76   0.000    -1873.673   -1547.343
------------------------------------------------------------------------------

. predict double eps, residual

. robvar eps, by(state)

           |        Summary of Residuals
     state |        Mean   Std. Dev.       Freq.
-----------+------------------------------------
        CT |    4.167853   1.3596266          20
        MA |    1.618796   .86550138          20
        ME |  -2.9841056   .93797625          20
        NH |   .51033312   .61139299          20
        RI |   -.8927223   .63408722          20
        VT |  -2.4201543   .71470977          20
-----------+------------------------------------
     Total |  -6.063e-14   2.6037101         120

W0  =  4.3882072   df(5, 114)     Pr > F = 0.00108562

W50 =  3.2989851   df(5, 114)     Pr > F = 0.00806751

W10 =  4.2536245   df(5, 114)     Pr > F = 0.00139064
```

6.2.2.2 *Feasible Generalized Least Squares Estimation*

```
. use NEdata.. regress dpipc year

      Source |       SS           df       MS      Number of obs   =       120
-------------+----------------------------------   F(1, 118)       =    440.17
       Model |  3009.33617         1  3009.33617   Prob > F        =    0.0000
    Residual |  806.737449       118  6.83675804   R-squared       =    0.7886
-------------+----------------------------------   Adj R-squared   =    0.7868
       Total |  3816.07362       119  32.0678456   Root MSE        =    2.6147

------------------------------------------------------------------------------
       dpipc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .8684582   .0413941    20.98   0.000     .7864865    .9504298
       _cons |  -1710.508   82.39534   -20.76   0.000    -1873.673   -1547.343
------------------------------------------------------------------------------

. predict double eps, residual

. by state, sort: egen sd_eps = sd(eps)
```

```
. generate double gw_wt = 1/sd_eps^2

. tabstat sd_eps gw_wt, by(state)

Summary statistics: mean
  by categories of: state

 state |    sd_eps     gw_wt
-------+--------------------
    CT |  1.359627  .5409545
    MA |  .8655014  1.334948
    ME |  .9379762  1.136623
    NH |   .611393  2.675218
    RI |  .6340872   2.48715
    VT |  .7147098  1.957675
-------+--------------------
 Total |  .8538824  1.688761
----------------------------

. regress dpipc year [aw = gw_wt]
(sum of wgt is 202.6513649171444)

      Source |       SS           df       MS      Number of obs   =       120
-------------+----------------------------------   F(1, 118)       =    698.19
       Model |  2845.55409         1  2845.55409   Prob > F        =    0.0000
    Residual |  480.921278       118  4.07560405   R-squared       =    0.8554
-------------+----------------------------------   Adj R-squared   =    0.8542
       Total |  3326.47537       119  27.9535745   Root MSE        =    2.0188

------------------------------------------------------------------------------
       dpipc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   .8444948   .0319602    26.42   0.000     .7812049    .9077847
       _cons |   -1663.26   63.61705   -26.14   0.000    -1789.239   -1537.281
------------------------------------------------------------------------------
```

6.2.3 *Heteroskedasticity in Grouped Data*

6.2.3.1 *Feasible Generalized Least Squares Estimation*

```
. use pubschl.. describe

Contains data from pubschl.dta
  obs:           420
 vars:            18                          2 Dec 2004 12:36
 size:        58,380
------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
------------------------------------------------------------------------------
observation_n~r float   %9.0g
dist_cod        float   %9.0g
county          str18   %18s
```

```
district        str53   %53s
gr_span         str8    %8s
enrl_tot        float   %9.0g
teachers        float   %9.0g
calw_pct        float   %9.0g
meal_pct        float   %9.0g
computer        float   %9.0g
testscr         float   %9.0g
comp_stu        float   %9.0g
expn_stu        float   %9.0g
str             float   %9.0g
avginc          float   %9.0g
el_pct          float   %9.0g
read_scr        float   %9.0g
math_scr        float   %9.0g
------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
observatio~r |        420       210.5    121.3878          1        420
    dist_cod |        420    67472.81    3466.995      61382      75440
      county |          0
    district |          0
     gr_span |          0
-------------+---------------------------------------------------------
    enrl_tot |        420    2628.793    3913.105         81      27176
    teachers |        420    129.0674    187.9127       4.85       1429
    calw_pct |        420    13.24604    11.45482          0    78.9942
    meal_pct |        420    44.70524    27.12338          0        100
    computer |        420    303.3833    441.3413          0       3324
-------------+---------------------------------------------------------
     testscr |        420    654.1565    19.05335     605.55     706.75
    comp_stu |        420    .1359266    .0649558          0   .4208333
    expn_stu |        420    5312.408    633.9371    3926.07   7711.507
         str |        420    19.64043    1.891812         14       25.8
      avginc |        420    15.31659     7.22589      5.335     55.328
-------------+---------------------------------------------------------
      el_pct |        420    15.76816    18.28593          0   85.53972
    read_scr |        420    654.9705    20.10798      604.5        704
    math_scr |        420    653.3426     18.7542      605.4      709.5

. regress read_scr expn_stu comp_stu meal_pct

      Source |       SS           df       MS      Number of obs   =       420
-------------+----------------------------------   F(3, 416)       =    565.36
       Model |  136046.267         3  45348.7558   Prob > F        =    0.0000
    Residual |  33368.3632       416  80.2124115   R-squared       =    0.8030
-------------+----------------------------------   Adj R-squared   =    0.8016
       Total |  169414.631       419  404.330861   Root MSE        =    8.9561

------------------------------------------------------------------------------
    read_scr |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    expn_stu |   .0046699   .0007204     6.48   0.000     .0032538     .006086
```

```
    comp_stu |   19.88584   7.168347     2.77   0.006     5.795143    33.97654
    meal_pct |   -.635131   .0164777   -38.54   0.000     -.667521    -.602741
       _cons |   655.8528   3.812206   172.04   0.000     648.3592    663.3464
------------------------------------------------------------------------------

. regress read_scr expn_stu comp_stu meal_pct [aw = enrl_tot]
(sum of wgt is 1,104,093)

      Source |       SS           df       MS      Number of obs   =       420
-------------+----------------------------------   F(3, 416)       =    906.75
       Model |  123692.671         3  41230.8903   Prob > F        =    0.0000
    Residual |  18915.9815       416  45.4711093   R-squared       =    0.8674
-------------+----------------------------------   Adj R-squared   =    0.8664
       Total |  142608.652       419  340.354779   Root MSE        =    6.7432

------------------------------------------------------------------------------
    read_scr |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    expn_stu |   .0055534   .0008322     6.67   0.000     .0039176    .0071892
    comp_stu |   27.26378   8.197228     3.33   0.001     11.15063    43.37693
    meal_pct |  -.6352229    .013149   -48.31   0.000    -.6610696   -.6093762
       _cons |    648.988   4.163875   155.86   0.000     640.8031    657.1728
------------------------------------------------------------------------------
```

6.3 SERIAL CORRELATION IN THE ERROR DISTRIBUTION

6.3.1 *Testing for Serial Correlation*

```
. use ukrates.. describe

Contains data from ukrates.dta
  obs:           526
 vars:             3                          2 Dec 2004 10:43
 size:         6,312
------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
------------------------------------------------------------------------------
rs              float   %9.0g
month           float   %tm
r20             float   %9.0g
------------------------------------------------------------------------------
Sorted by: month

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
          rs |        526    7.651513    3.553109   1.561667      16.18
       month |        526       168.5    151.9874        -94        431
         r20 |        526    8.863726    3.224372       3.35      17.18

. regress D.rs LD.r20
```

```
      Source |       SS           df       MS      Number of obs   =       524
-------------+----------------------------------   F(1, 522)       =     52.88
       Model |  13.8769739         1  13.8769739   Prob > F        =    0.0000
    Residual |  136.988471       522  .262430021   R-squared       =    0.0920
-------------+----------------------------------   Adj R-squared   =    0.0902
       Total |  150.865445       523  .288461654   Root MSE        =    .51228

------------------------------------------------------------------------------
        D.rs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         r20 |
         LD. |   .4882883   .0671484     7.27   0.000      .356374    .6202027
             |
       _cons |   .0040183    .022384     0.18   0.858    -.0399555    .0479921
------------------------------------------------------------------------------

. predict double eps, residual
(2 missing values generated)

. estat bgodfrey, lags(6)

Breusch-Godfrey LM test for autocorrelation
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       6     |         17.237               6                   0.0084
---------------------------------------------------------------------------
                       H0: no serial correlation

. wntestq eps

Portmanteau test for white noise
---------------------------------------
 Portmanteau (Q) statistic =    82.3882
 Prob > chi2(40)           =     0.0001

. ac eps
```

6.3.2 *FGLS Estimation with Serial Correlation*

```
. use ukrates.. regress D.rs LD.r20

      Source |       SS           df       MS      Number of obs   =       524
-------------+----------------------------------   F(1, 522)       =     52.88
       Model |  13.8769739         1  13.8769739   Prob > F        =    0.0000
    Residual |  136.988471       522  .262430021   R-squared       =    0.0920
-------------+----------------------------------   Adj R-squared   =    0.0902
       Total |  150.865445       523  .288461654   Root MSE        =    .51228

------------------------------------------------------------------------------
        D.rs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         r20 |
         LD. |   .4882883   .0671484     7.27   0.000      .356374    .6202027
```

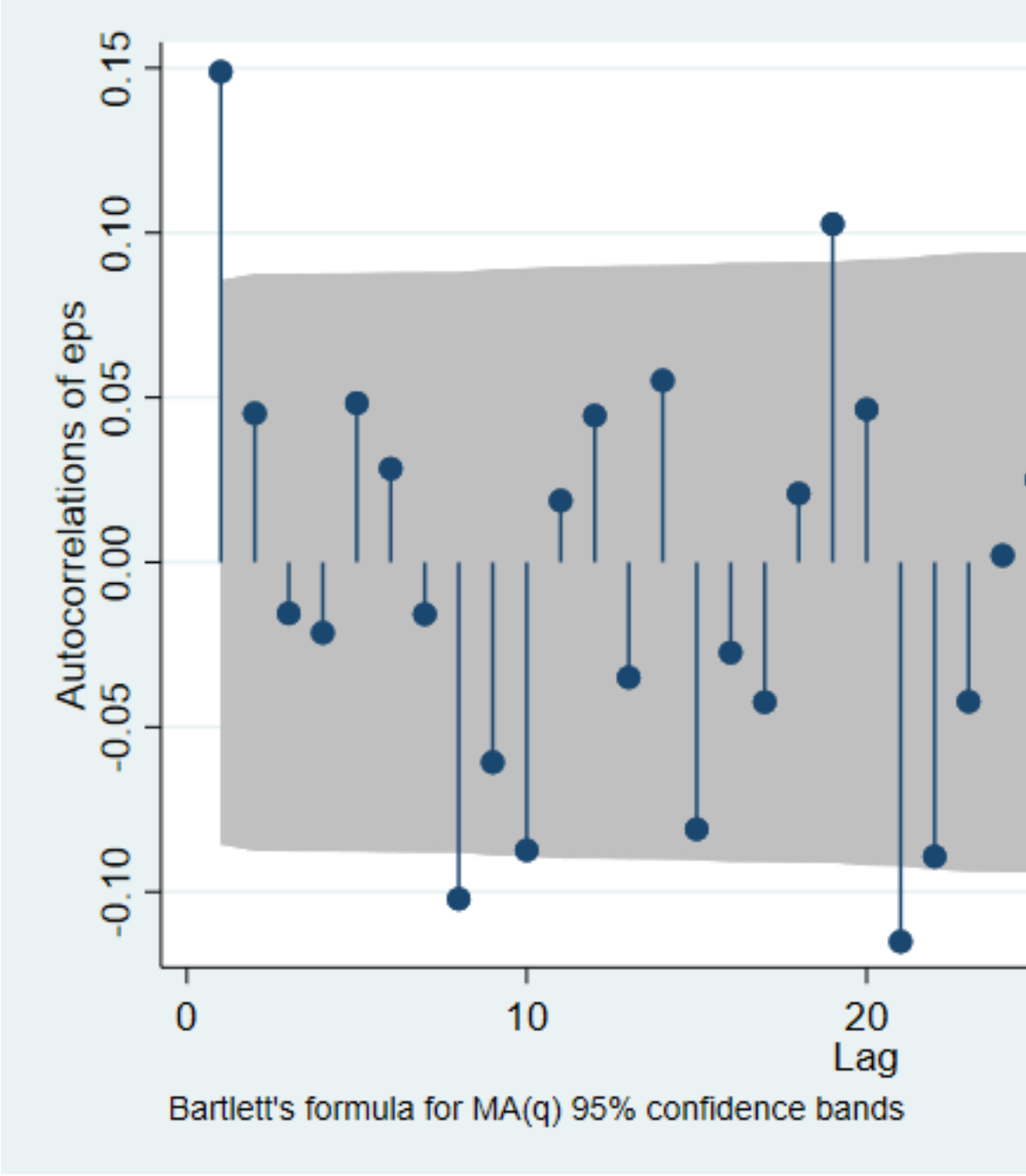

Figure 6: Autocorrelogram of regression residuals

```
             |
       _cons |   .0040183    .022384     0.18   0.858    -.0399555    .0479921
------------------------------------------------------------------------------

. prais D.rs LD.r20, nolog


Prais-Winsten AR(1) regression -- iterated estimates

      Source |       SS           df       MS      Number of obs   =       524
-------------+----------------------------------   F(1, 522)       =     25.73
       Model |  6.56420242         1  6.56420242   Prob > F        =    0.0000
    Residual |  133.146932       522   .25507075   R-squared       =    0.0470
-------------+----------------------------------   Adj R-squared   =    0.0452
       Total |  139.711134       523    .2671341   Root MSE        =    .50505

------------------------------------------------------------------------------
        D.rs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         r20 |
         LD. |   .3495857    .068912     5.07   0.000     .2142067    .4849647
             |
       _cons |   .0049985   .0272145     0.18   0.854    -.0484649    .0584619
-------------+----------------------------------------------------------------
         rho |   .1895324
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    1.702273
Durbin-Watson statistic (transformed) 2.007414
```

7

REGRESSION WITH INDICATOR VARIABLES

7.1 TESTING FOR SIGNIFICANCE OF A QUALITATIVE FACTOR

7.1.1 *Regression with One Qualitative Measure*

```
. use NEdata.. describe

Contains data from NEdata.dta
  obs:           120
 vars:             6                          24 Oct 2004 13:28
 size:         2,640
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
state           long    %8.0g      state
year            int     %8.0g
pop             float   %9.0g
dpi             float   %9.0g
dpipc           float   %9.0g
ldpipc          float   %9.0g
-------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
       state |        120         3.5    1.714986          1          6
        year |        120      1990.5    5.790459       1981       2000
         pop |        120     2196276     1931629     515594    6362076
         dpi |        120    4.33e+07    4.46e+07    4385134   1.93e+08
       dpipc |        120    18.15802    5.662848   8.153382   33.38758
-------------+--------------------------------------------------------
      ldpipc |        120    2.848302    .3265395   2.098433   3.508184

. mean dpipc, over(state)

Mean estimation                   Number of obs   =        120

           CT: state = CT
           MA: state = MA
           ME: state = ME
           NH: state = NH
           RI: state = RI
           VT: state = VT

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

```
        Over |       Mean   Std. Err.     [95% Conf. Interval]
-------------+------------------------------------------------
dpipc        |
          CT |   22.32587   1.413766      19.52647    25.12527
          MA |   19.77681   1.298507      17.20564    22.34798
          ME |   15.17391   .9571251      13.27871    17.06911
          NH |   18.66835   1.193137      16.30582    21.03088
          RI |   17.26529   1.045117      15.19586    19.33473
          VT |   15.73786   1.020159      13.71784    17.75788
------------------------------------------------------------

. tabulate state, generate(NE)

      state |      Freq.     Percent        Cum.
------------+-----------------------------------
         CT |         20       16.67       16.67
         MA |         20       16.67       33.33
         ME |         20       16.67       50.00
         NH |         20       16.67       66.67
         RI |         20       16.67       83.33
         VT |         20       16.67      100.00
------------+-----------------------------------
      Total |        120      100.00

. regress dpipc NE2-NE6

      Source |       SS           df       MS      Number of obs   =       120
-------------+----------------------------------   F(5, 114)       =      5.27
       Model |  716.218512         5  143.243702   Prob > F        =    0.0002
    Residual |  3099.85511       114  27.1917115   R-squared       =    0.1877
-------------+----------------------------------   Adj R-squared   =    0.1521
       Total |  3816.07362       119  32.0678456   Root MSE        =    5.2146

------------------------------------------------------------------------------
       dpipc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         NE2 |  -2.549057   1.648991    -1.55   0.125    -5.815695    .7175814
         NE3 |  -7.151959   1.648991    -4.34   0.000     -10.4186    -3.88532
         NE4 |   -3.65752   1.648991    -2.22   0.029    -6.924158   -.3908815
         NE5 |  -5.060575   1.648991    -3.07   0.003    -8.327214   -1.793937
         NE6 |  -6.588007   1.648991    -4.00   0.000    -9.854646   -3.321369
       _cons |   22.32587   1.166013    19.15   0.000     20.01601    24.63573
------------------------------------------------------------------------------

. use NEdata.. tabulate state, generate(NE)

      state |      Freq.     Percent        Cum.
------------+-----------------------------------
         CT |         20       16.67       16.67
         MA |         20       16.67       33.33
         ME |         20       16.67       50.00
         NH |         20       16.67       66.67
         RI |         20       16.67       83.33
         VT |         20       16.67      100.00
------------+-----------------------------------
      Total |        120      100.00
```

```
. forvalues i = 1/5 {
  2.   generate NE_‘i’ = NE‘i’ - NE6
  3.   }

. regress dpipc NE_*

      Source |       SS           df       MS      Number of obs   =       120
-------------+----------------------------------   F(5, 114)       =      5.27
       Model |  716.218512         5  143.243702   Prob > F        =    0.0002
    Residual |  3099.85511       114  27.1917115   R-squared       =    0.1877
-------------+----------------------------------   Adj R-squared   =    0.1521
       Total |  3816.07362       119  32.0678456   Root MSE        =    5.2146

------------------------------------------------------------------------------
       dpipc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        NE_1 |   4.167853   1.064419     3.92   0.000     2.059247    6.276459
        NE_2 |   1.618796   1.064419     1.52   0.131      -.48981    3.727402
        NE_3 |  -2.984106   1.064419    -2.80   0.006    -5.092712   -.8754996
        NE_4 |   .5103331   1.064419     0.48   0.633    -1.598273    2.618939
        NE_5 |  -.8927223   1.064419    -0.84   0.403    -3.001328    1.215884
       _cons |   18.15802   .4760227    38.15   0.000     17.21502    19.10101
------------------------------------------------------------------------------

.
. lincom -(NE_1 + NE_2 + NE_3 + NE_4 + NE_5)

 ( 1)  - NE_1 - NE_2 - NE_3 - NE_4 - NE_5 = 0

------------------------------------------------------------------------------
       dpipc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -2.420154   1.064419    -2.27   0.025     -4.52876   -.3115483
------------------------------------------------------------------------------
```

7.1.2 *Regression with Two Qualitative Measures*

```
. use nlsw88.(NLSW, 1988 extract)

. describe

Contains data from nlsw88.dta
  obs:         2,246                          NLSW, 1988 extract
 vars:            17                          21 Jun 2006 11:33
 size:        60,642                          (_dta has notes)
------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
------------------------------------------------------------------------------
idcode          int     %8.0g                 NLS id
age             byte    %8.0g                 age in current year
race            byte    %8.0g      racelbl    race
married         byte    %8.0g      marlbl     married
```

```
never_married   byte    %8.0g                 never married
grade           byte    %8.0g                 current grade completed
collgrad        byte    %16.0g      gradlbl   college graduate
south           byte    %8.0g                 lives in south
smsa            byte    %9.0g       smsalbl   lives in SMSA
c_city          byte    %8.0g                 lives in central city
industry        byte    %23.0g      indlbl    industry
occupation      byte    %22.0g      occlbl    occupation
union           byte    %8.0g       unionlbl  union worker
wage            float   %9.0g                 hourly wage
hours           byte    %8.0g                 usual hours worked
ttl_exp         float   %9.0g                 total work experience
tenure          float   %9.0g                 job tenure (years)
------------------------------------------------------------------------------
Sorted by: idcode

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
      idcode |      2,246    2612.654    1480.864          1       5159
         age |      2,246    39.15316    3.060002         34         46
        race |      2,246    1.282725    .4754413          1          3
     married |      2,246    .6420303    .4795099          0          1
never_marr~d |      2,246    .1041852    .3055687          0          1
-------------+---------------------------------------------------------
       grade |      2,244    13.09893    2.521246          0         18
    collgrad |      2,246    .2368655    .4252538          0          1
       south |      2,246    .4194123    .4935728          0          1
        smsa |      2,246    .7039181    .4566292          0          1
      c_city |      2,246    .2916296    .4546139          0          1
-------------+---------------------------------------------------------
    industry |      2,232    8.189516    3.010875          1         12
  occupation |      2,237    4.642825    3.408897          1         13
       union |      1,878    .2454739    .4304825          0          1
        wage |      2,246    7.766949    5.755523   1.004952   40.74659
       hours |      2,242    37.21811    10.50914          1         80
-------------+---------------------------------------------------------
     ttl_exp |      2,246    12.53498    4.610208   .1153846   28.88461
      tenure |      2,231     5.97785    5.510331          0   25.91667

. keep if !missing(wage + race + union)
(368 observations deleted)

. generate lwage = log(wage)

. tabulate race, generate(R)

       race |      Freq.     Percent        Cum.
------------+-----------------------------------
      white |      1,353       72.04       72.04
      black |        501       26.68       98.72
      other |         24        1.28      100.00
------------+-----------------------------------
      Total |      1,878      100.00

. regress lwage R1 R2 union
```

```
      Source |       SS           df       MS      Number of obs   =     1,878
-------------+----------------------------------   F(3, 1874)      =     38.73
       Model |  29.3349228         3  9.77830761   Prob > F        =    0.0000
    Residual |  473.119209     1,874  .252464893   R-squared       =    0.0584
-------------+----------------------------------   Adj R-squared   =    0.0569
       Total |  502.454132     1,877  .267690001   Root MSE        =    .50246

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          R1 |  -.0349326   .1035125    -0.34   0.736    -.2379444    .1680793
          R2 |  -.2133924   .1049954    -2.03   0.042    -.4193126   -.0074721
       union |    .239083   .0270353     8.84   0.000     .1860606    .2921054
       _cons |   1.913178   .1029591    18.58   0.000     1.711252    2.115105
------------------------------------------------------------------------------

. test R1 R2

 ( 1)  R1 = 0
 ( 2)  R2 = 0

       F(  2,  1874) =   23.25
            Prob > F =    0.0000
```

7.1.2.1 *Interaction Effects*

```
. use nlsw88.(NLSW, 1988 extract)

. keep if !missing(wage + race + union)
(368 observations deleted)

. generate lwage = log(wage)

. tabulate race, generate(R)

       race |      Freq.     Percent        Cum.
------------+-----------------------------------
      white |      1,353       72.04       72.04
      black |        501       26.68       98.72
      other |         24        1.28      100.00
------------+-----------------------------------
      Total |      1,878      100.00

. generate R1u = R1 * union

. generate R2u = R2 * union

. regress lwage R1 R2 union R1u R2u

      Source |       SS           df       MS      Number of obs   =     1,878
-------------+----------------------------------   F(5, 1872)      =     26.63
       Model |  33.3636017         5  6.67272035   Prob > F        =    0.0000
    Residual |   469.09053     1,872  .250582548   R-squared       =    0.0664
-------------+----------------------------------   Adj R-squared   =    0.0639
```

```
       Total |  502.454132     1,877  .267690001   Root MSE        =    .50058

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          R1 |  -.1818955   .1260945    -1.44   0.149    -.4291962    .0654051
          R2 |  -.4152863   .1279741    -3.25   0.001    -.6662731   -.1642995
       union |  -.2375316   .2167585    -1.10   0.273    -.6626452     .187582
         R1u |   .4232627   .2192086     1.93   0.054    -.0066561    .8531816
         R2u |   .6193578   .2221704     2.79   0.005     .1836302    1.055085
       _cons |    2.07205   .1251456    16.56   0.000      1.82661    2.317489
------------------------------------------------------------------------------

. test R1u R2u

 ( 1)  R1u = 0
 ( 2)  R2u = 0

       F(  2,  1872) =    8.04
            Prob > F =    0.0003
```

7.2 REGRESSION WITH QUALITATIVE & QUANTITATIVE FACTORS

```
. use nlsw88.(NLSW, 1988 extract)

. keep if !missing(wage + race + union)
(368 observations deleted)

. generate lwage = log(wage)

. tabulate race, generate(R)

       race |      Freq.     Percent        Cum.
------------+-----------------------------------
      white |      1,353       72.04       72.04
      black |        501       26.68       98.72
      other |         24        1.28      100.00
------------+-----------------------------------
      Total |      1,878      100.00

. regress lwage R1 R2 union tenure

      Source |       SS           df       MS      Number of obs   =     1,868
-------------+----------------------------------   F(4, 1863)      =     85.88
       Model |  77.1526731         4  19.2881683   Prob > F        =    0.0000
    Residual |  418.434693     1,863  .224602626   R-squared       =    0.1557
-------------+----------------------------------   Adj R-squared   =    0.1539
       Total |  495.587366     1,867  .265445831   Root MSE        =    .47392

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          R1 |   -.070349   .0976711    -0.72   0.471    -.2619053    .1212073
          R2 |  -.2612185   .0991154    -2.64   0.008    -.4556074   -.0668297
```

```
       union |   .1871116   .0257654     7.26   0.000     .1365794    .2376438
      tenure |   .0289352   .0019646    14.73   0.000     .0250823    .0327882
       _cons |   1.777386   .0975549    18.22   0.000     1.586058    1.968715
------------------------------------------------------------------------------

. test R1 R2

 ( 1)  R1 = 0
 ( 2)  R2 = 0

       F(  2,  1863) =   29.98
            Prob > F =    0.0000
```

7.2.1 *Testing for Slope Differences*

```
. use nlsw88.(NLSW, 1988 extract)

. keep if !missing(wage + race + union)
(368 observations deleted)

. generate lwage = log(wage)

. tabulate race, generate(R)

       race |      Freq.     Percent        Cum.
------------+-----------------------------------
      white |      1,353       72.04       72.04
      black |        501       26.68       98.72
      other |         24        1.28      100.00
------------+-----------------------------------
      Total |      1,878      100.00

. generate uTen = union * tenure
(10 missing values generated)

. regress lwage R1 R2 union tenure uTen

      Source |       SS           df       MS      Number of obs   =     1,868
-------------+----------------------------------   F(5, 1862)      =     69.27
       Model |   77.726069         5  15.5452138   Prob > F        =    0.0000
    Residual |  417.861297     1,862  .224415304   R-squared       =    0.1568
-------------+----------------------------------   Adj R-squared   =    0.1546
       Total |  495.587366     1,867  .265445831   Root MSE        =    .47372

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          R1 |  -.0715443   .0976332    -0.73   0.464    -.2630264    .1199377
          R2 |  -.2638742   .0990879    -2.66   0.008    -.4582093   -.0695391
       union |   .2380442   .0409706     5.81   0.000      .157691    .3183975
      tenure |   .0309616   .0023374    13.25   0.000     .0263774    .0355458
        uTen |  -.0068913   .0043112    -1.60   0.110    -.0153467     .001564
       _cons |   1.766484   .0977525    18.07   0.000     1.574768      1.9582
------------------------------------------------------------------------------
```

```
.
. generate R1ten = R1 * tenure
(10 missing values generated)

. generate R2ten = R2 * tenure
(10 missing values generated)

. regress lwage R1 R2 union tenure R1ten R2ten

      Source |       SS           df       MS      Number of obs   =     1,868
-------------+----------------------------------   F(6, 1861)      =     57.26
       Model |  77.2369283         6  12.8728214   Prob > F        =    0.0000
    Residual |  418.350438     1,861  .224798731   R-squared       =    0.1558
-------------+----------------------------------   Adj R-squared   =    0.1531
       Total |  495.587366     1,867  .265445831   Root MSE        =    .47413

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          R1 |   -.082753      .1395    -0.59   0.553    -.3563459    .1908398
          R2 |   -.291495   .1422361    -2.05   0.041     -.570454    -.012536
       union |   .1876079   .0257915     7.27   0.000     .1370246    .2381912
      tenure |   .0257611   .0186309     1.38   0.167    -.0107785    .0623007
       R1ten |   .0024973   .0187646     0.13   0.894    -.0343045    .0392991
       R2ten |   .0050825    .018999     0.27   0.789     -.032179    .0423441
       _cons |   1.794018   .1382089    12.98   0.000     1.522957    2.065078
------------------------------------------------------------------------------

. test R1ten R2ten

 ( 1)  R1ten = 0
 ( 2)  R2ten = 0

       F(  2,  1861) =    0.19
            Prob > F =    0.8291

.
. regress lwage R1 R2 union tenure uTen R1ten R2ten

      Source |       SS           df       MS      Number of obs   =     1,868
-------------+----------------------------------   F(7, 1860)      =     49.48
       Model |  77.8008722         7  11.1144103   Prob > F        =    0.0000
    Residual |  417.786494     1,860  .224616394   R-squared       =    0.1570
-------------+----------------------------------   Adj R-squared   =    0.1538
       Total |  495.587366     1,867  .265445831   Root MSE        =    .47394

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          R1 |  -.0697096   .1396861    -0.50   0.618    -.3436676    .2042485
          R2 |  -.2795277   .1423788    -1.96   0.050    -.5587668   -.0002886
       union |    .238244   .0410597     5.80   0.000     .1577161    .3187718
      tenure |   .0304528   .0188572     1.61   0.106    -.0065308    .0674364
        uTen |  -.0068628   .0043311    -1.58   0.113    -.0153572    .0016316
       R1ten |  -.0001912   .0188335    -0.01   0.992    -.0371283    .0367459
       R2ten |   .0023429   .0190698     0.12   0.902    -.0350576    .0397433
```

```
       _cons |    1.76904   .1390492    12.72   0.000     1.496331    2.041749
------------------------------------------------------------------------------

. test uTen R1ten R2ten

 ( 1)  uTen = 0
 ( 2)  R1ten = 0
 ( 3)  R2ten = 0

       F(  3,  1860) =    0.96
            Prob > F =    0.4098

.
. regress lwage union tenure uTen

      Source |       SS           df       MS      Number of obs   =     1,868
-------------+----------------------------------   F(3, 1864)      =     92.25
       Model |  64.0664855         3  21.3554952   Prob > F        =    0.0000
    Residual |   431.52088     1,864  .231502618   R-squared       =    0.1293
-------------+----------------------------------   Adj R-squared   =    0.1279
       Total |  495.587366     1,867  .265445831   Root MSE        =    .48115

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       union |   .2144586   .0414898     5.17   0.000     .1330872      .29583
      tenure |   .0298926   .0023694    12.62   0.000     .0252456    .0345395
        uTen |  -.0056219   .0043756    -1.28   0.199    -.0142035    .0029597
       _cons |   1.655054   .0193938    85.34   0.000     1.617018     1.69309
------------------------------------------------------------------------------

.
. regress lwage tenure if !union

      Source |       SS           df       MS      Number of obs   =     1,408
-------------+----------------------------------   F(1, 1406)      =    148.43
       Model |  36.8472972         1  36.8472972   Prob > F        =    0.0000
    Residual |  349.032053     1,406  .248244703   R-squared       =    0.0955
-------------+----------------------------------   Adj R-squared   =    0.0948
       Total |   385.87935     1,407  .274256823   Root MSE        =    .49824

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      tenure |   .0298926   .0024536    12.18   0.000     .0250795    .0347056
       _cons |   1.655054   .0200828    82.41   0.000     1.615659     1.69445
------------------------------------------------------------------------------

. predict double unw if e(sample), res
(470 missing values generated)

.
. regress lwage tenure if union

      Source |       SS           df       MS      Number of obs   =       460
-------------+----------------------------------   F(1, 458)       =     55.95
       Model |  10.0775663         1  10.0775663   Prob > F        =    0.0000
```

```
    Residual |  82.4888278       458  .180106611   R-squared       =    0.1089
-------------+----------------------------------   Adj R-squared   =    0.1069
       Total |  92.5663941       459  .201669704   Root MSE        =    .42439

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      tenure |   .0242707   .0032447     7.48   0.000     .0178944    .0306469
       _cons |   1.869513   .0323515    57.79   0.000     1.805937    1.933088
------------------------------------------------------------------------------

. predict double nunw if e(sample), res
(1,418 missing values generated)

.
. generate double allres = nunw
(1,418 missing values generated)

. replace allres = unw if unw <.
(1,408 real changes made)

. sdtest allres, by(union)

Variance ratio test
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
nonunion |   1,408    7.51e-17    .0132735    .4980645   -.0260379    .0260379
   union |     460    3.33e-17    .0197657    .4239271   -.0388425    .0388425
---------+--------------------------------------------------------------------
combined |   1,868    6.48e-17    .0111235    .4807605   -.0218157    .0218157
------------------------------------------------------------------------------
    ratio = sd(nonunion) / sd(union)                              f =   1.3803
Ho: ratio = 1                                 degrees of freedom = 1407, 459

    Ha: ratio < 1               Ha: ratio != 1                 Ha: ratio > 1
  Pr(F < f) = 1.0000         2*Pr(F > f) = 0.0000           Pr(F > f) = 0.0000

.
. regress lwage union tenure uTen, robust

Linear regression                               Number of obs     =      1,868
                                                F(3, 1864)        =     109.84
                                                Prob > F          =     0.0000
                                                R-squared         =     0.1293
                                                Root MSE          =     .48115

------------------------------------------------------------------------------
             |               Robust
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       union |   .2144586   .0407254     5.27   0.000     .1345864    .2943308
      tenure |   .0298926   .0023964    12.47   0.000     .0251928    .0345924
        uTen |  -.0056219   .0038631    -1.46   0.146    -.0131984    .0019546
       _cons |   1.655054   .0210893    78.48   0.000     1.613693    1.696415
------------------------------------------------------------------------------
```

```
. use turksales.. describe

Contains data from turksales.dta
  obs:            40
 vars:             2                          21 Jun 2006 11:33
 size:           320                          (_dta has notes)
------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
------------------------------------------------------------------------------
t               float   %tq
sales           float   %9.0g
------------------------------------------------------------------------------
Sorted by: t

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
           t |         40       139.5    11.69045        120        159
       sales |         40    105.6178    4.056961   97.84603   112.9617

. summarize sales, meanonly

. generate mu = r(mean)

. forvalues i=1/3 {
  2.     generate qseas`i'= (quarter(dofq(t)) == `i')
  3. }

. regress sales qseas*

      Source |       SS           df       MS      Number of obs   =        40
-------------+----------------------------------   F(3, 36)        =      4.03
       Model |  161.370376         3  53.7901254   Prob > F        =    0.0143
    Residual |   480.52796        36  13.3479989   R-squared       =    0.2514
-------------+----------------------------------   Adj R-squared   =    0.1890
       Total |  641.898336        39  16.4589317   Root MSE        =    3.6535

------------------------------------------------------------------------------
       sales |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      qseas1 |  -5.232047   1.633891    -3.20   0.003    -8.545731   -1.918362
      qseas2 |  -2.842753   1.633891    -1.74   0.090    -6.156437    .4709317
      qseas3 |  -.8969368   1.633891    -0.55   0.586    -4.210621    2.416748
       _cons |   107.8608   1.155335    93.36   0.000     105.5177    110.2039
------------------------------------------------------------------------------

. predict double salesSA, residual

. replace salesSA = salesSA + mu
(40 real changes made)
```

```
. summarize sales salesSA

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
       sales |         40    105.6178    4.056961   97.84603   112.9617
     salesSA |         40    105.6178    3.510161   97.49429   111.9563

.
. label var salesSA "sales, seasonally adjusted"

. tsline sales salesSA, lpattern(solid dash)

.
. regress sales qseas* t

      Source |       SS           df       MS      Number of obs   =        40
-------------+----------------------------------   F(4, 35)        =     54.23
       Model |  552.710487         4  138.177622   Prob > F        =    0.0000
    Residual |  89.1878487        35  2.54822425   R-squared       =    0.8611
-------------+----------------------------------   Adj R-squared   =    0.8452
       Total |  641.898336        39  16.4589317   Root MSE        =    1.5963

------------------------------------------------------------------------------
       sales |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      qseas1 |  -4.415311   .7169299    -6.16   0.000    -5.870756   -2.959866
      qseas2 |  -2.298262   .7152449    -3.21   0.003    -3.750287    -.846238
      qseas3 |  -.6246916   .7142321    -0.87   0.388     -2.07466    .8252766
           t |   .2722452   .0219686    12.39   0.000     .2276466    .3168438
       _cons |   69.47421   3.138432    22.14   0.000     63.10285    75.84556
------------------------------------------------------------------------------

. test qseas1 qseas2 qseas3

 ( 1)  qseas1 = 0
 ( 2)  qseas2 = 0
 ( 3)  qseas3 = 0

       F(  3,    35) =   15.17
            Prob > F =    0.0000

. predict double salesSADT, residual

. replace salesSADT = salesSADT + mu
(40 real changes made)

.
. label var salesSADT "sales, detrende and SA"

. tsline sales salesSADT, lpattern(solid dash) yline(‘mu’)
```

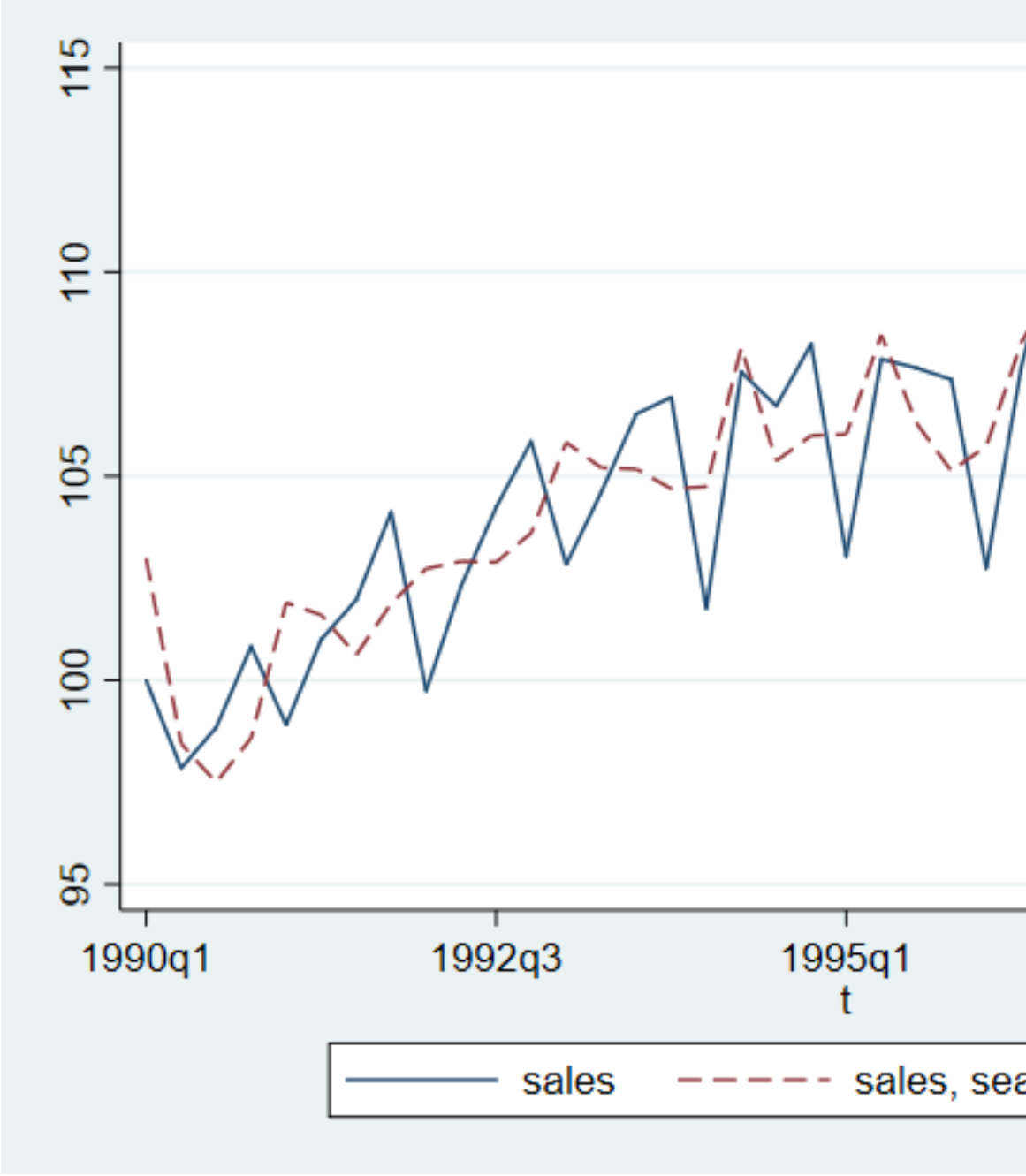

Figure 7: Seasonal adjustment of time series

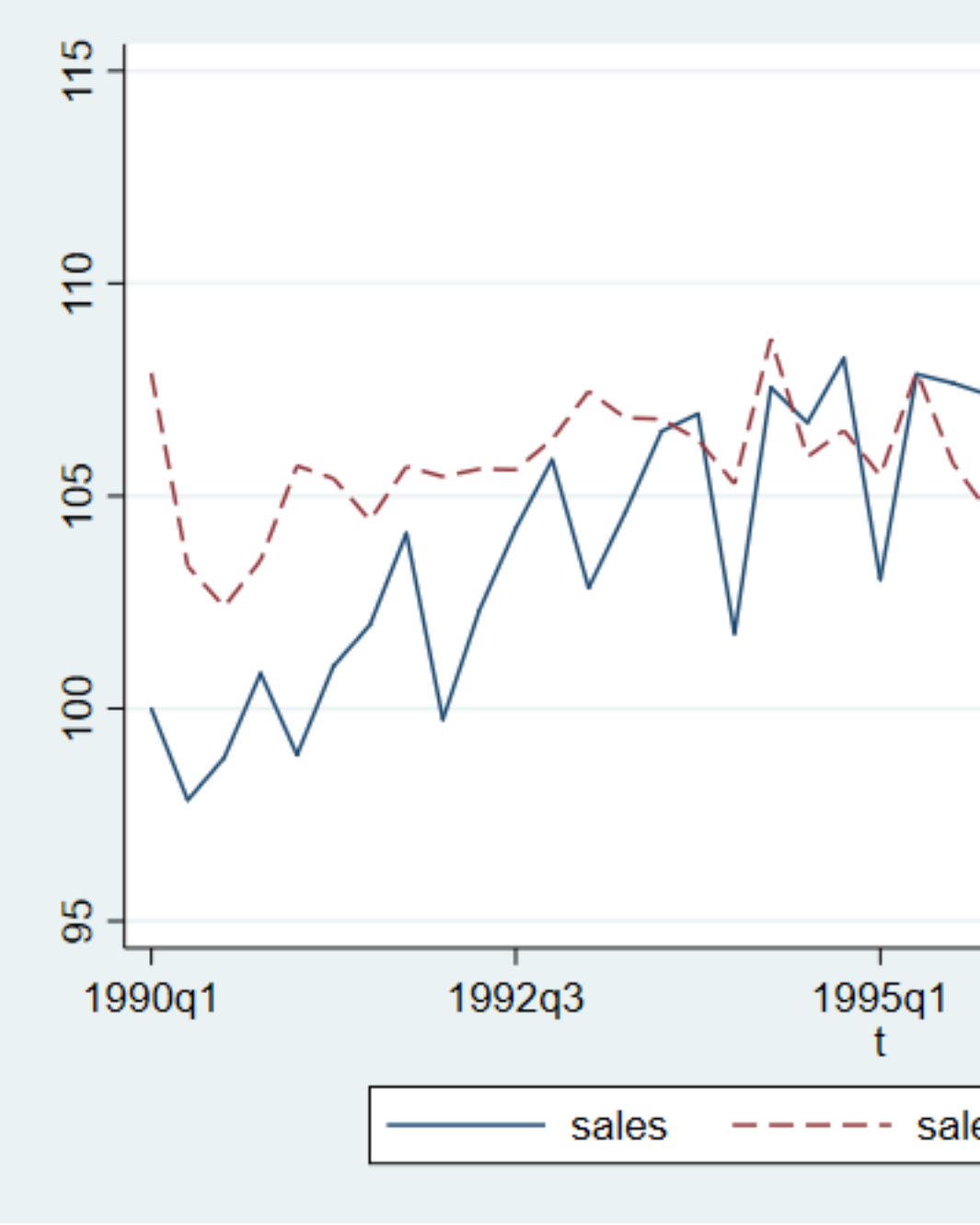

Figure 8: Seasonal adjustment and deterending of time series

7.4.1 *Constraints of Continuity & Differentiability*

```
. use nlsw88.(NLSW, 1988 extract)

. describe

Contains data from nlsw88.dta
  obs:         2,246                          NLSW, 1988 extract
 vars:            17                          21 Jun 2006 11:33
 size:        60,642                          (_dta has notes)
------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
------------------------------------------------------------------------------
idcode          int     %8.0g                 NLS id
age             byte    %8.0g                 age in current year
race            byte    %8.0g      racelbl    race
married         byte    %8.0g      marlbl     married
never_married   byte    %8.0g                 never married
grade           byte    %8.0g                 current grade completed
collgrad        byte    %16.0g     gradlbl    college graduate
south           byte    %8.0g                 lives in south
smsa            byte    %9.0g      smsalbl    lives in SMSA
c_city          byte    %8.0g                 lives in central city
industry        byte    %23.0g     indlbl     industry
occupation      byte    %22.0g     occlbl     occupation
union           byte    %8.0g      unionlbl   union worker
wage            float   %9.0g                 hourly wage
hours           byte    %8.0g                 usual hours worked
ttl_exp         float   %9.0g                 total work experience
tenure          float   %9.0g                 job tenure (years)
------------------------------------------------------------------------------
Sorted by: idcode

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
      idcode |      2,246    2612.654    1480.864          1       5159
         age |      2,246    39.15316    3.060002         34         46
        race |      2,246    1.282725    .4754413          1          3
     married |      2,246    .6420303    .4795099          0          1
never_marr~d |      2,246    .1041852    .3055687          0          1
-------------+--------------------------------------------------------
       grade |      2,244    13.09893    2.521246          0         18
    collgrad |      2,246    .2368655    .4252538          0          1
       south |      2,246    .4194123    .4935728          0          1
        smsa |      2,246    .7039181    .4566292          0          1
      c_city |      2,246    .2916296    .4546139          0          1
-------------+--------------------------------------------------------
    industry |      2,232    8.189516    3.010875          1         12
  occupation |      2,237    4.642825    3.408897          1         13
       union |      1,878    .2454739    .4304825          0          1
```

```
        wage |      2,246    7.766949    5.755523   1.004952   40.74659
       hours |      2,242    37.21811    10.50914          1         80
-------------+---------------------------------------------------------
     ttl_exp |      2,246    12.53498    4.610208   .1153846   28.88461
      tenure |      2,231     5.97785    5.510331          0   25.91667

. generate lwage = log(wage)

. generate Ten2 = tenure <= 2

. generate Ten7 = !Ten2 & tenure <= 7

. generate Ten12 = !Ten2 & !Ten7 & tenure <= 12

. generate Ten25 = !Ten2 & !Ten7 & !Ten12 & tenure < .

.
. generate tTen2 = tenure * Ten2
(15 missing values generated)

. generate tTen7 = tenure * Ten7
(15 missing values generated)

. generate tTen12 = tenure * Ten12
(15 missing values generated)

. generate tTen25 = tenure * Ten25
(15 missing values generated)

.
. regress lwage Ten* tTen*, nocons hascons

      Source |       SS           df       MS      Number of obs   =     2,231
-------------+----------------------------------   F(7, 2223)      =     37.12
       Model |  76.6387069         7  10.9483867   Prob > F        =    0.0000
    Residual |  655.578361     2,223  .294907045   R-squared       =    0.1047
-------------+----------------------------------   Adj R-squared   =    0.1018
       Total |  732.217068     2,230  .328348461   Root MSE        =    .54305

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        Ten2 |    1.55662   .0383259    40.62   0.000     1.481462    1.631778
        Ten7 |   1.708728    .060084    28.44   0.000     1.590901    1.826554
       Ten12 |   1.870808   .1877798     9.96   0.000     1.502566     2.23905
       Ten25 |   1.751961   .1691799    10.36   0.000     1.420194    2.083728
       tTen2 |   .0897426   .0331563     2.71   0.007     .0247221    .1547631
       tTen7 |   .0434089   .0140739     3.08   0.002     .0158095    .0710083
      tTen12 |   .0154208    .019786     0.78   0.436    -.0233801    .0542218
      tTen25 |   .0238014   .0102917     2.31   0.021     .0036191    .0439837
------------------------------------------------------------------------------

. predict double lwagehat
(option xb assumed; fitted values)
(15 missing values generated)

.
```

```
. label var lwagehat "Predicted log(wage)"

. sort tenure

.
. twoway (line lwagehat tenure if tenure <= 2) (line lwagehat tenure if tenure
> > 2  & tenure <= 7) (line lwagehat tenure if tenure > 7  & tenure <= 12) (lin
> e lwagehat tenure if tenure > 12  & tenure < .), legend(off)


.
. mkspline sTen2 2 sTen7 7 sTen12 12 sTen25 = tenure

. regress lwage sTen*

      Source |       SS           df       MS      Number of obs   =     2,231
-------------+----------------------------------   F(4, 2226)      =     64.55
       Model |  76.1035947         4  19.0258987   Prob > F        =    0.0000
    Residual |  656.113473     2,226  .294749988   R-squared       =    0.1039
-------------+----------------------------------   Adj R-squared   =    0.1023
       Total |  732.217068     2,230  .328348461   Root MSE        =    .54291

------------------------------------------------------------------------------
       lwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       sTen2 |   .1173168   .0248619     4.72   0.000     .0685619    .1660716
       sTen7 |   .0471177    .009448     4.99   0.000       .02859    .0656455
      sTen12 |   .0055041   .0111226     0.49   0.621    -.0163076    .0273158
      sTen25 |   .0237767   .0083618     2.84   0.005      .007379    .0401744
       _cons |   1.539985   .0359605    42.82   0.000     1.469465    1.610505
------------------------------------------------------------------------------

.
. predict double lwageSpline
(option xb assumed; fitted values)
(15 missing values generated)

.
. label var lwageSpline "Predicted log(wage), splined"

. twoway line lwageSpline tenure

.
```

7.4.2 *Structural Change in a Time Series Model*

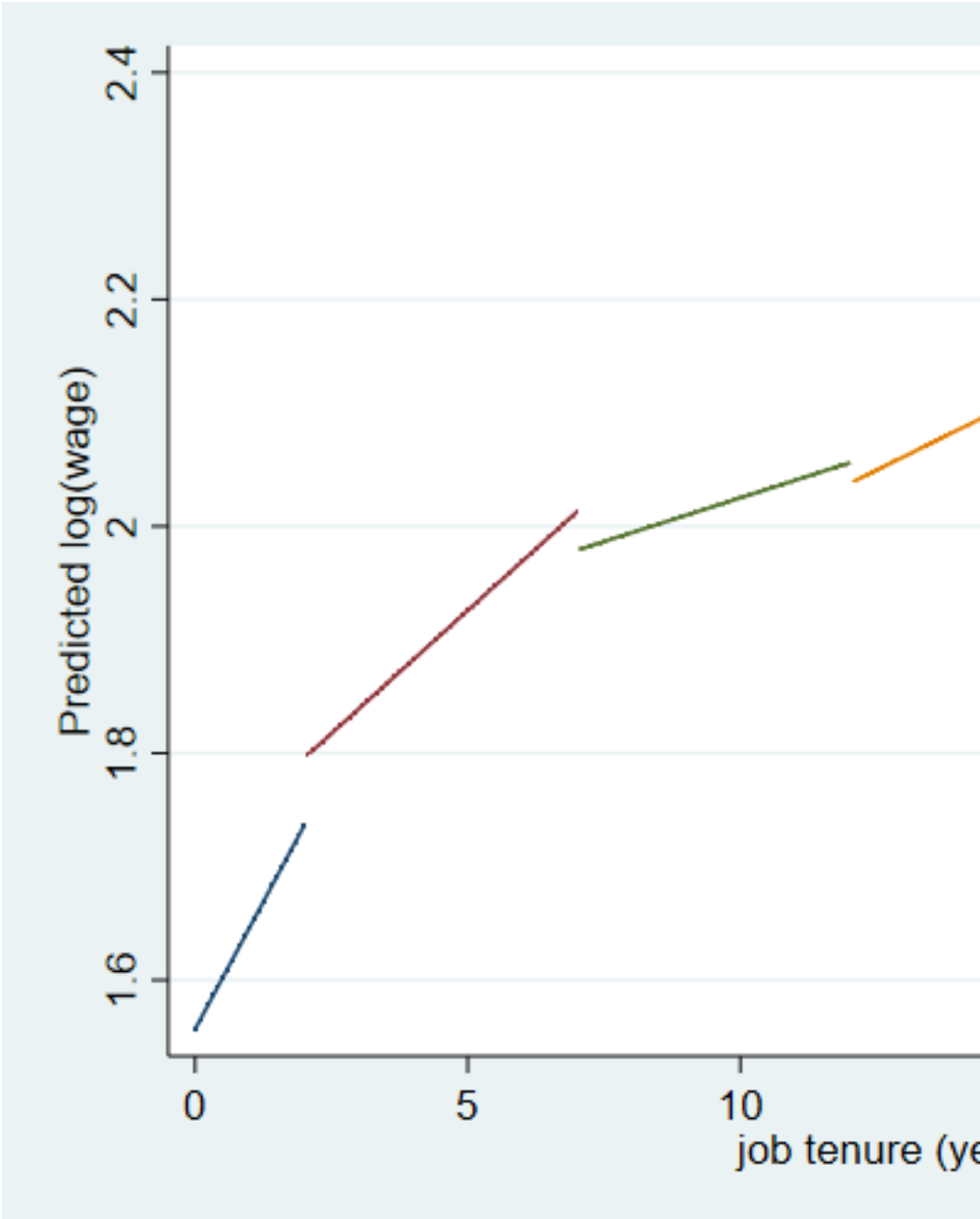

Figure 9: Piecewise wage-tenure profile

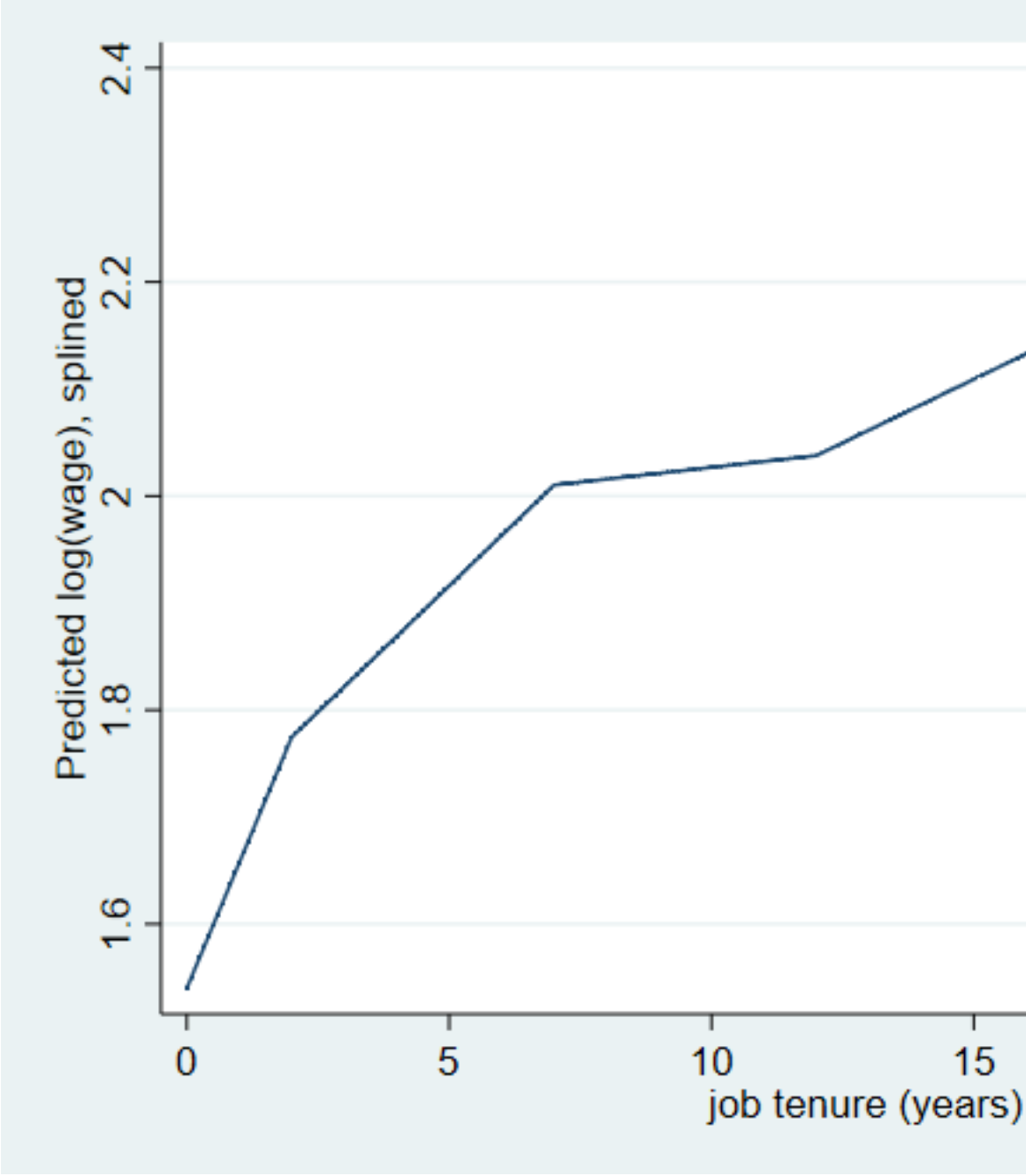

Figure 10: Piecewise linear wage-tenure profile

8

INSTRUMENTAL VARIABLES ESTIMATORS

8.1 INTRODUCTION

8.2 ENDOGENEITY IN ECONOMIC RELATIONSHIPS

8.3 2SLS

8.4 THE IVREG COMMAND

8.5 IDENTIFICATION & TESTS OF OVERIDENTIFYING RESTRICTIONS

8.6 COMPUTING IV ESTIMATES


```
. use griliches.(Wages of Very Young Men, Zvi Griliches, J.Pol.Ec. 1976)

. describe

Contains data from griliches.dta
  obs:           758                          Wages of Very Young Men, Zvi
                                                Griliches, J.Pol.Ec. 1976
 vars:            26                          31 Oct 2004 14:12
 size:        65,188
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
rns             float   %9.0g                 residency in South
rns80           float   %9.0g
mrt             float   %9.0g                 marital status = 1 if married
mrt80           float   %9.0g
smsa            float   %9.0g                 reside metro area = 1 if urban
smsa80          float   %9.0g
med             float   %9.0g                 mother's education, years
iq              float   %9.0g                 iq score
kww             float   %9.0g                 score on knowledge in world of
                                                work test
year            float   %9.0g
age             float   %9.0g
age80           float   %9.0g
s               float   %9.0g                 completed years of schooling
s80             float   %9.0g
expr            float   %9.0g                 experience, years
expr80          float   %9.0g
tenure          float   %9.0g                 tenure, years
tenure80        float   %9.0g
```

```
lw              float   %9.0g                 log wage
lw80            float   %9.0g
_Iyear_67       byte    %8.0g                 year==67
_Iyear_68       byte    %8.0g                 year==68
_Iyear_69       byte    %8.0g                 year==69
_Iyear_70       byte    %8.0g                 year==70
_Iyear_71       byte    %8.0g                 year==71
_Iyear_73       byte    %8.0g                 year==73
-------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
         rns |        758    .2691293    .4438001          0          1
       rns80 |        758     .292876    .4553825          0          1
         mrt |        758    .5145119    .5001194          0          1
       mrt80 |        758    .8984169    .3022988          0          1
        smsa |        758    .7044855     .456575          0          1
-------------+---------------------------------------------------------
      smsa80 |        758    .7124011     .452942          0          1
         med |        758    10.91029     2.74112          0         18
          iq |        758    103.8562    13.61867         54        145
         kww |        758    36.57388    7.302247         12         56
        year |        758    69.03166    2.631794         66         73
-------------+---------------------------------------------------------
         age |        758    21.83509    2.981756         16         30
       age80 |        758    33.01187    3.085504         28         38
           s |        758    13.40501    2.231828          9         18
         s80 |        758    13.70712    2.214693          9         18
        expr |        758    1.735429    2.105542          0     11.444
-------------+---------------------------------------------------------
      expr80 |        758    11.39426    4.210745       .692     22.045
      tenure |        758    1.831135     1.67363          0         10
    tenure80 |        758    7.362797     5.05024          0         22
          lw |        758    5.686739    .4289494      4.605      7.051
        lw80 |        758    6.826555    .4099268      4.749      8.032
-------------+---------------------------------------------------------
   _Iyear_67 |        758    .0831135    .2762359          0          1
   _Iyear_68 |        758    .1042216    .3057496          0          1
   _Iyear_69 |        758    .1121372    .3157435          0          1
   _Iyear_70 |        758    .0844327    .2782193          0          1
   _Iyear_71 |        758     .121372    .3267747          0          1
-------------+---------------------------------------------------------
   _Iyear_73 |        758    .2084433    .4064636          0          1


. use griliches.(Wages of Very Young Men, Zvi Griliches, J.Pol.Ec. 1976)

. ivreg lw s expr tenure rns smsa _I* (iq=med kww age mrt), first

First-stage regressions
-----------------------

      Source |       SS           df       MS      Number of obs   =       758
-------------+----------------------------------   F(15, 742)      =     25.03
```

```
       Model |  47176.4676        15  3145.09784   Prob > F        =    0.0000
    Residual |  93222.8583       742  125.637275   R-squared       =    0.3360
-------------+----------------------------------   Adj R-squared   =    0.3226
       Total |  140399.326       757  185.468066   Root MSE        =    11.209

------------------------------------------------------------------------------
          iq |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           s |   2.497742   .2858159     8.74   0.000     1.936638    3.058846
        expr |   -.033548   .2534458    -0.13   0.895    -.5311042    .4640082
      tenure |   .6158215   .2731146     2.25   0.024     .0796522    1.151991
         rns |  -2.610221   .9499731    -2.75   0.006    -4.475177   -.7452663
        smsa |   .0260481   .9222585     0.03   0.977    -1.784499    1.836595
   _Iyear_67 |   .9254935   1.655969     0.56   0.576    -2.325449    4.176436
   _Iyear_68 |   .4706951   1.574561     0.30   0.765    -2.620429     3.56182
   _Iyear_69 |   2.164635   1.521387     1.42   0.155    -.8221007     5.15137
   _Iyear_70 |   5.734786   1.696033     3.38   0.001     2.405191    9.064381
   _Iyear_71 |   5.180639   1.562156     3.32   0.001     2.113866    8.247411
   _Iyear_73 |   4.526686    1.48294     3.05   0.002     1.615429    7.437943
         med |   .2877745   .1622338     1.77   0.077    -.0307176    .6062665
         kww |   .4581116   .0699323     6.55   0.000     .3208229    .5954003
         age |  -.8809144   .2232535    -3.95   0.000    -1.319198   -.4426307
         mrt |   -.584791    .946056    -0.62   0.537    -2.442056    1.272474
       _cons |   67.20449   4.107281    16.36   0.000     59.14121    75.26776
------------------------------------------------------------------------------


Instrumental variables (2SLS) regression

      Source |       SS           df       MS      Number of obs   =       758
-------------+----------------------------------   F(12, 745)      =     45.91
       Model |  59.2679161        12  4.93899301   Prob > F        =    0.0000
    Residual |  80.0182337       745  .107407025   R-squared       =    0.4255
-------------+----------------------------------   Adj R-squared   =    0.4163
       Total |   139.28615       757  .183997556   Root MSE        =    .32773

------------------------------------------------------------------------------
          lw |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          iq |   .0001747   .0039374     0.04   0.965    -.0075551    .0079044
           s |   .0691759    .013049     5.30   0.000     .0435587    .0947931
        expr |    .029866    .006697     4.46   0.000     .0167189    .0430132
      tenure |   .0432738   .0076934     5.62   0.000     .0281705     .058377
         rns |  -.1035897   .0297371    -3.48   0.001    -.1619682   -.0452111
        smsa |   .1351148   .0268889     5.02   0.000     .0823277    .1879019
   _Iyear_67 |   -.052598   .0481067    -1.09   0.275    -.1470388    .0418428
   _Iyear_68 |   .0794686   .0451078     1.76   0.079     -.009085    .1680222
   _Iyear_69 |   .2108962   .0443153     4.76   0.000     .1238984    .2978939
   _Iyear_70 |   .2386338   .0514161     4.64   0.000     .1376962    .3395714
   _Iyear_71 |   .2284609   .0441236     5.18   0.000     .1418396    .3150823
   _Iyear_73 |   .3258944   .0410718     7.93   0.000     .2452642    .4065247
       _cons |    4.39955   .2708771    16.24   0.000     3.867777    4.931323
------------------------------------------------------------------------------
Instrumented:  iq
Instruments:   s expr tenure rns smsa _Iyear_67 _Iyear_68 _Iyear_69
               _Iyear_70 _Iyear_71 _Iyear_73 med kww age mrt
------------------------------------------------------------------------------
```

8.7 ivreg2 & gmm estimation

8.7.1 *The GMM Estimator*

8.7.2 *GMM in a Homoskedastic Context*

8.7.3 *GMM & Heteroskedasticity-Consistent Standard Errors*

```
. use griliches.(Wages of Very Young Men, Zvi Griliches, J.Pol.Ec. 1976)

. ivreg2 lw s expr tenure rns smsa _I* (iq=med kww age mrt), gmm
command ivreg2 is unrecognized
r(199);

end of do-file
r(199);
```

8.7.4 *GMM & Clustering*

8.7.5 *GMM & HAC Standard Errors*

8.8 testing & overidentifying restrictions in gmm

8.8.1 *Testing a subset of the Overidentifying Restrictions in GMM*

8.9 testing for heteroskedasticity in the iv context

8.10 testing the relevance of instruments

8.11 durbin–wu–hausman tests for endogeneity in iv estimation

9

PANEL DATA MODELS

9.1 FIXED EFFECTS & RANDOM EFFECTS MODELS

9.1.1 *One-Way Fixed Effects Models*

```
. use traffic.. describe

Contains data from traffic.dta
  obs:           336
 vars:            54                          30 Nov 2004 10:23
 size:        61,152
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
state           float   %9.0g      sid        State ID (FIPS) Code
year            int     %9.0g                 Year
spircons        float   %9.0g                 Spirits Consumption
unrate          float   %9.0g                 Unemployment Rate
perinc          float   %9.0g                 Per Capita Personal Income
emppop          float   %9.0g                 Employment/Population Ratio
beertax         float   %9.0g                 Tax on Case of Beer
sobapt          float   %9.0g                 % Southern Baptist
mormon          float   %9.0g                 % Mormon
mlda            float   %9.0g                 Minimum Legal Drinking Age
dry             float   %9.0g                 % Residing in Dry Counties
yngdrv          float   %9.0g                 % of Drivers Aged 15-24
vmiles          float   %9.0g                 Ave. Mile per Driver
breath          byte    %9.0g                 Prelim. Breath Test Law
jaild           byte    %9.0g                 Mandatory Jail Sentence
comserd         byte    %9.0g                 Mandatory Community Service
allmort         int     %9.0g                 # of Vehicle Fatalities (#VF)
mrall           float   %9.0g                 Vehicle Fatality Rate (VFR)
allnite         int     %9.0g                 # of Night-time VF (#NVF)
mralln          float   %9.0g                 Night-time VFR (NFVR)
allsvn          int     %9.0g                 # of Single VF (#SVN)
a1517           int     %9.0g                 #VF, 15-17 year olds
mra1517         float   %9.0g                 VFR, 15-17 year olds
a1517n          byte    %9.0g                 #NVF, 15-17 year olds
mra1517n        float   %9.0g                 NVFR, 15-17 year olds
a1820           int     %9.0g                 #VF, 18-20 year olds
a1820n          int     %9.0g                 #NVF, 18-20 year olds
mra1820         float   %9.0g                 VFR, 18-20 year olds
mra1820n        float   %9.0g                 NVFR, 18-20 year olds
a2124           int     %9.0g                 #VF, 21-24 year olds
mra2124         float   %9.0g                 VFR, 21-24 year olds
a2124n          int     %9.0g                 #NVF, 21-24 year olds
mra2124n        float   %9.0g                 NVFR, 21-24 year olds
```

```
aidall          float   %9.0g                 # of alcohol-involved VF
mraidall        float   %9.0g                 Alcohol-Involved VFR
pop             float   %9.0g                 Population
pop1517         float   %9.0g                 Population, 15-17 year olds
pop1820         float   %9.0g                 Population, 18-20 year olds
pop2124         float   %9.0g                 Population, 21-24 year olds
miles           float   %9.0g                 total vehicle miles (millions
unus            float   %9.0g                 U.S. unemployment rate
epopus          float   %9.0g                 U.S. Emp/Pop Ratio
gspch           float   %9.0g                 GSP Rate of Change
stabrv          str2    %9s
region          str2    %9s
reg             long    %8.0g      reg
fatal           float   %9.0g
fatal1517       float   %9.0g
fatal1820       float   %9.0g
fatal2124       float   %9.0g
fatal1517n      float   %9.0g
fatal1820n      float   %9.0g
fatal2124n      float   %9.0g
perincK         float   %9.0g
--------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
       state |        336     30.1875    15.30985          1         56
        year |        336        1985    2.002983       1982       1988
    spircons |        336     1.75369    .6835745        .79        4.9
      unrate |        336    7.346726    2.533405        2.4         18
      perinc |        336    13880.18    2253.046   9513.762   22193.46
-------------+---------------------------------------------------------
      emppop |        336    60.80568    4.721656    42.9932   71.26865
     beertax |        336     .513256    .4778442   .0433109   2.720764
      sobapt |        336    7.156925    9.762621          0    30.3557
      mormon |        336    2.801933    9.665279         .1    65.9165
        mlda |        336    20.45563    .8990255         18         21
-------------+---------------------------------------------------------
         dry |        336    4.267074    9.500901          0    45.7921
      yngdrv |        336    .1859299    .0248736    .073137    .281625
      vmiles |        336    7890.754    1475.659   4576.346   26148.27
      breath |        336    .4613095    .4992443          0          1
       jaild |        335     .280597     .449963          0          1
-------------+---------------------------------------------------------
     comserd |        335    .1850746     .388939          0          1
     allmort |        336    928.6637    934.0515         79       5504
       mrall |        336     .000204     .000057   .0000821   .0004218
     allnite |        336    182.5833    188.4311         13       1049
      mralln |        336    .0000388     .000011   .0000172   .0000944
-------------+---------------------------------------------------------
      allsvn |        336    109.9494    108.5397          8        603
       a1517 |        336    62.61012    55.72909          3        318
     mra1517 |        336    .0003034    .0000937   .0001163   .0006735
      a1517n |        336     12.2619    12.25341          0         76
    mra1517n |        336    .0000598     .000033          0   .0002571
```

```
-------------+--------------------------------------------------------
       a1820 |        336    106.6607    104.2236          7        601
      a1820n |        336    33.52679    33.23834          0        196
     mra1820 |        336    .0004728    .0001522   .0001855   .0010952
    mra1820n |        336    .0001436    .0000613          0   .0005238
       a2124 |        336     126.872    131.7886         12        770
-------------+--------------------------------------------------------
     mra2124 |        336    .0004091    .0001225      .0002   .0008922
      a2124n |        336    41.37798    42.93031          1        249
    mra2124n |        336    .0001284    .0000422   .0000222   .0003143
      aidall |        336    293.3332    303.5807       24.6     2094.9
    mraidall |        336    .0000659     .000026   .0000234   .0001772
-------------+--------------------------------------------------------
         pop |        336     4930272     5073704   478999.7   2.83e+07
     pop1517 |        336    230815.5    229896.3   21000.02    1172000
     pop1820 |        336    249090.4    249345.6   20999.96    1321004
     pop2124 |        336    336389.9    345304.4   30000.16    1892998
       miles |        336    37101.49    37454.37       3993     241575
-------------+--------------------------------------------------------
        unus |        336    7.528571    1.479376        5.5        9.7
      epopus |        336    59.97143    1.585048       57.8       62.3
       gspch |        336    .0253135    .0431732  -.1236415   .1423609
      stabrv |          0
      region |          0
-------------+--------------------------------------------------------
         reg |        336    2.395833     1.16971          1          4
       fatal |        336    2.040444    .5701938     .82121    4.21784
   fatal1517 |        336    3.033664    .9374229    1.16279    6.73469
   fatal1820 |        336    4.727677    1.521962   1.854922    10.9524
   fatal2124 |        336    4.091315    1.224812          2    8.92157
-------------+--------------------------------------------------------
  fatal1517n |        336     .597681    .3297287          0    2.57143
  fatal1820n |        336    1.436218    .6128804          0     5.2381
  fatal2124n |        336    1.284335    .4224502     .22222    3.14286
     perincK |        336    13.88018    2.253046   9.513762   22.19345

. xtsum fatal beertax spircons unrate perincK state year

Variable         |      Mean   Std. Dev.       Min        Max |    Observations
-----------------+--------------------------------------------+----------------
fatal    overall |  2.040444   .5701938     .82121    4.21784 |     N =      336
         between |             .5461407   1.110077   3.653197 |     n =       48
         within  |             .1794253    1.45556   2.962664 |     T =        7
                 |                                          |
beertax  overall |   .513256   .4778442   .0433109   2.720764 |     N =      336
         between |             .4789513   .0481679   2.440507 |     n =       48
         within  |             .0552203   .1415352   .7935126 |     T =        7
                 |                                          |
spircons overall |   1.75369   .6835745        .79        4.9 |     N =      336
         between |             .6734649   .8614286   4.388572 |     n =       48
         within  |              .147792   1.255119   2.265119 |     T =        7
                 |                                          |
unrate   overall |  7.346726   2.533405        2.4         18 |     N =      336
         between |             1.953377        4.1       13.2 |     n =       48
         within  |             1.634257   4.046726   12.14673 |     T =        7
                 |                                          |
perincK  overall |  13.88018   2.253046   9.513762   22.19345 |     N =      336
```

```
         between |            2.122712    9.95087   19.51582 |     n =      48
         within  |            .8068546   11.43261   16.55782 |     T =       7
                 |                                           |
state    overall |   30.1875   15.30985          1         56 |     N =     336
         between |            15.44883          1         56 |     n =      48
         within  |                   0    30.1875    30.1875 |     T =       7
                 |                                           |
year     overall |      1985   2.002983       1982       1988 |     N =     336
         between |                   0       1985       1985 |     n =      48
         within  |            2.002983       1982       1988 |     T =       7


. use traffic.. xtreg fatal beertax spircons unrate perincK, fe

Fixed-effects (within) regression               Number of obs     =         336
Group variable: state                           Number of groups  =          48

R-sq:                                           Obs per group:
     within  = 0.3526                                         min =           7
     between = 0.1146                                         avg =         7.0
     overall = 0.0863                                         max =           7

                                                F(4,284)          =       38.68
corr(u_i, Xb)  = -0.8804                        Prob > F          =      0.0000

------------------------------------------------------------------------------
       fatal |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |  -.4840728   .1625106    -2.98   0.003    -.8039508   -.1641948
    spircons |   .8169652   .0792118    10.31   0.000     .6610484    .9728819
      unrate |  -.0290499   .0090274    -3.22   0.001    -.0468191   -.0112808
     perincK |   .1047103   .0205986     5.08   0.000      .064165    .1452555
       _cons |   -.383783   .4201781    -0.91   0.362    -1.210841    .4432754
-------------+----------------------------------------------------------------
     sigma_u |  1.1181913
     sigma_e |  .15678965
         rho |  .98071823   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(47, 284) = 59.77                     Prob > F = 0.0000
```

9.1.2 *Time Effects & Two-Way Fixed Effects Models*

```
. use traffic.. tabulate year, generate(yr)

       Year |      Freq.     Percent        Cum.
------------+-----------------------------------
       1982 |         48       14.29       14.29
       1983 |         48       14.29       28.57
       1984 |         48       14.29       42.86
       1985 |         48       14.29       57.14
       1986 |         48       14.29       71.43
       1987 |         48       14.29       85.71
       1988 |         48       14.29      100.00
------------+-----------------------------------
```

```
      Total |        336      100.00

.
. local j 0

. forvalues i=82/87 {
  2.   local ++j
  3.   rename yr`j' yr`i'
  4.   quietly replace yr`i' = yr`i' - yr7
  5. }

.
. drop yr7

.
. xtreg fatal beertax spircons unrate perincK yr*, fe

Fixed-effects (within) regression               Number of obs     =        336
Group variable: state                           Number of groups  =         48

R-sq:                                           Obs per group:
     within  = 0.4528                                         min =          7
     between = 0.1090                                         avg =        7.0
     overall = 0.0770                                         max =          7

                                                F(10,278)         =      23.00
corr(u_i, Xb)  = -0.8728                        Prob > F          =     0.0000

------------------------------------------------------------------------------
       fatal |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |  -.4347195   .1539564    -2.82   0.005    -.7377878   -.1316511
    spircons |    .805857   .1126425     7.15   0.000     .5841163    1.027598
      unrate |  -.0549084   .0103418    -5.31   0.000    -.0752666   -.0345502
     perincK |   .0882636   .0199988     4.41   0.000     .0488953    .1276319
        yr82 |   .1004321   .0355629     2.82   0.005     .0304253     .170439
        yr83 |   .0470609   .0321574     1.46   0.144    -.0162421    .1103638
        yr84 |  -.0645507   .0224667    -2.87   0.004    -.1087771   -.0203243
        yr85 |  -.0993055   .0198667    -5.00   0.000    -.1384139   -.0601971
        yr86 |   .0496288   .0232525     2.13   0.034     .0038554    .0954021
        yr87 |   .0003593   .0289315     0.01   0.990    -.0565933    .0573119
       _cons |   .0286246   .4183346     0.07   0.945    -.7948812    .8521305
-------------+----------------------------------------------------------------
     sigma_u |  1.0987683
     sigma_e |  .14570531
         rho |  .98271904   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(47, 278) = 64.52                     Prob > F = 0.0000

. test yr82 yr83 yr84 yr85 yr86 yr87

 ( 1)  yr82 = 0
 ( 2)  yr83 = 0
 ( 3)  yr84 = 0
 ( 4)  yr85 = 0
 ( 5)  yr86 = 0
 ( 6)  yr87 = 0
```

```
       F(  6,   278) =    8.48
            Prob > F =    0.0000
```

9.1.3 *The Between Estimator*

```
. use traffic.. xtreg fatal beertax spircons unrate perincK, be

Between regression (regression on group means)  Number of obs     =        336
Group variable: state                           Number of groups  =         48

R-sq:                                           Obs per group:
     within  = 0.0479                                         min =          7
     between = 0.4565                                         avg =        7.0
     overall = 0.2583                                         max =          7

                                                F(4,43)           =       9.03
sd(u_i + avg(e_i.))=  .4209489                  Prob > F          =     0.0000

------------------------------------------------------------------------------
       fatal |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |   .0740362   .1456333     0.51   0.614    -.2196614    .3677338
    spircons |   .2997517   .1128135     2.66   0.011     .0722417    .5272618
      unrate |   .0322333    .038005     0.85   0.401    -.0444111    .1088776
     perincK |  -.1841747   .0422241    -4.36   0.000    -.2693277   -.0990218
       _cons |   3.796343   .7502025     5.06   0.000     2.283415    5.309271
------------------------------------------------------------------------------
```

9.1.4 *One-Way Random Effects Models*

```
. use traffic.. xtreg fatal beertax spircons unrate perincK, re

Random-effects GLS regression                   Number of obs     =        336
Group variable: state                           Number of groups  =         48

R-sq:                                           Obs per group:
     within  = 0.2263                                         min =          7
     between = 0.0123                                         avg =        7.0
     overall = 0.0042                                         max =          7

                                                Wald chi2(4)      =      49.90
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
       fatal |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     beertax |   .0442768   .1204613     0.37   0.713     -.191823    .2803765
    spircons |   .3024711   .0642954     4.70   0.000     .1764546    .4284877
      unrate |  -.0491381   .0098197    -5.00   0.000    -.0683843   -.0298919
     perincK |  -.0110727   .0194746    -0.57   0.570    -.0492423    .0270968
```

```
       _cons |   2.001973   .3811247     5.25   0.000     1.254983    2.748964
-------------+----------------------------------------------------------------
     sigma_u |  .41675665
     sigma_e |  .15678965
         rho |  .87601197   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

9.1.5 *Testing the appropriateness of Random Effects Model*

```
. use traffic.. quietly xtreg fatal beertax spircons unrate perincK, fe

. estimates store fix

.
. quietly xtreg fatal beertax spircons unrate perincK, re

. estimates store ran

.
. hausman fix ran

                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fix          ran         Difference          S.E.
-------------+----------------------------------------------------------------
     beertax |   -.4840728     .0442768       -.5283495        .1090815
    spircons |    .8169652     .3024711         .514494        .0462668
      unrate |   -.0290499    -.0491381        .0200882               .
     perincK |    .1047103    -.0110727         .115783        .0067112
------------------------------------------------------------------------------
                           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(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      130.93
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)

.
```

9.1.6 *Prediction from One-Way Fixed Effects Model & Random Effects Model*

9.2 IV MODELS FOR PANEL DATA

9.3 DYNAMIC PANEL DATA MODELS

```
. use traffic.. tsset
```

```
       panel variable:  state (strongly balanced)
        time variable:  year, 1982 to 1988
                delta:  1 unit

. xtabond2 fatal L.fatal spircons year, gmmstyle(beertax spircons unrate perinc
> K) ivstyle(year) twostep robust nolevelq
command xtabond2 is unrecognized
r(199);

end of do-file
r(199);
```

9.4 SEEMINGLY UNRELATED REGRESSION MODELS

9.4.1 *SUR with Identical Regressors*

9.5 MOVING-WINDOW REGRESSION ESTIMATES

10

MODELS OF DISCRETE & LIMITED DEPENDENT VARIABLES

10.1 BINOMIAL LOGIT & PROBIT MODELS

10.1.1 *The Latent Variable Approach*

10.1.2 *Marginal Effects & Predictions*

10.1.2.1 *Binomial Probit*

```
. use womenwk.. describe

Contains data from womenwk.dta
  obs:         2,000
 vars:            15                          9 Nov 2004 20:23
 size:       134,000
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
c1              double  %10.0g
c2              double  %10.0g
u               double  %10.0g
v               double  %10.0g
county          float   %9.0g
age             int     %8.0g
education       int     %8.0g
married         byte    %8.0g
children        int     %8.0g
select          float   %9.0g
wagefull        float   %9.0g
wage            float   %9.0g
lw              float   %9.0g
work            float   %9.0g
lwf             float   %9.0g
-------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
          c1 |      2,000   -.0023069    .9880571  -3.500514   3.614182
          c2 |      2,000   -.0077596    1.006025  -3.410111   3.423961
           u |      2,000   -.0011535    .4940286  -1.750257   1.807091
           v |      2,000   -.0071367           1  -3.954782   3.229851
      county |      2,000         4.5       2.873          0          9
```

```
-------------+--------------------------------------------------------
         age |      2,000      36.208     8.28656         20         59
   education |      2,000      13.084    3.045912         10         20
     married |      2,000       .6705    .4701492          0          1
    children |      2,000      1.6445    1.398963          0          5
      select |      2,000    35.78556    14.98163  -14.45688   89.63869
-------------+--------------------------------------------------------
    wagefull |      2,000    21.31176    7.012038  -1.680425   45.80979
        wage |      1,343    23.69217    6.305374    5.88497   45.80979
          lw |      1,343    3.126703    .2865111   1.772402   3.824498
        work |      2,000       .6715    .4697852          0          1
         lwf |      2,000    2.099581    1.487519          0   3.824498

.
. probit work age married children education, nolog

Probit regression                                 Number of obs     =      2,000
                                                  LR chi2(4)        =     478.32
                                                  Prob > chi2       =     0.0000
Log likelihood = -1027.0616                       Pseudo R2         =     0.1889

------------------------------------------------------------------------------
        work |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .0347211   .0042293     8.21   0.000     .0264318    .0430105
     married |   .4308575    .074208     5.81   0.000     .2854125    .5763025
    children |   .4473249   .0287417    15.56   0.000     .3909922    .5036576
   education |   .0583645   .0109742     5.32   0.000     .0368555    .0798735
       _cons |  -2.467365   .1925635   -12.81   0.000    -2.844782   -2.089948
------------------------------------------------------------------------------

. mfx compute

Marginal effects after probit
      y  = Pr(work) (predict)
         =  .71835948
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     age |    .011721      .00142    8.25   0.000   .008935  .014507    36.208
 married*|    .150478      .02641    5.70   0.000   .098716   .20224     .6705
children |   .1510059      .00922   16.38   0.000   .132939  .169073    1.6445
educat~n |   .0197024       .0037    5.32   0.000   .012442  .026963    13.084
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1

.
. margeff, dummies(married) count
command margeff is unrecognized
r(199);

end of do-file
r(199);
```

```
. use womenwk..
. logit work age married children education, nolog

Logistic regression                               Number of obs     =      2,000
                                                  LR chi2(4)        =     476.62
                                                  Prob > chi2       =     0.0000
Log likelihood = -1027.9144                       Pseudo R2         =     0.1882

------------------------------------------------------------------------------
        work |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .0579303    .007221     8.02   0.000     .0437773    .0720833
     married |   .7417775   .1264705     5.87   0.000     .4938998    .9896552
    children |   .7644882   .0515289    14.84   0.000     .6634935     .865483
   education |   .0982513   .0186522     5.27   0.000     .0616936     .134809
       _cons |  -4.159247   .3320401   -12.53   0.000    -4.810034   -3.508461
------------------------------------------------------------------------------

. mfx compute

Marginal effects after logit
      y  = Pr(work) (predict)
         =  .72678588
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     age |   .0115031      .00142    8.08   0.000   .008713  .014293    36.208
 married*|   .1545671      .02703    5.72   0.000   .101592  .207542     .6705
children |    .151803      .00938   16.19   0.000   .133425  .170181    1.6445
educat~n |   .0195096       .0037    5.27   0.000    .01226   .02676    13.084
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1

. mfx compute, at(children = 0)

warning: no value assigned in at() for variables age married education;
   means used for age married education

Marginal effects after logit
      y  = Pr(work) (predict)
         =  .43074191
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     age |   .0142047      .00178    7.97   0.000    .01071    .0177    36.208
 married*|   .1762562      .02825    6.24   0.000   .120897  .231616     .6705
children |    .187455      .01115   16.82   0.000   .165609  .209301         0
educat~n |   .0240915      .00458    5.26   0.000   .015115  .033068    13.084
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

```
. use panel84extract.. describe

Contains data from panel84extract.dta
  obs:            98
 vars:            38                          1 Dec 2004 23:14
 size:        14,896
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
s77             float   %9.0g
s78             float   %9.0g
s79             float   %9.0g
s80             float   %9.0g
s81             float   %9.0g
s82             float   %9.0g
s83             float   %9.0g
b77             float   %9.0g
b78             float   %9.0g
b79             float   %9.0g
b80             float   %9.0g
b81             float   %9.0g
b82             float   %9.0g
b83             float   %9.0g
is77            float   %9.0g
is78            float   %9.0g
is79            float   %9.0g
is80            float   %9.0g
is81            float   %9.0g
is82            float   %9.0g
is83            float   %9.0g
ia77            float   %9.0g
ia78            float   %9.0g
ia79            float   %9.0g
ia80            float   %9.0g
ia81            float   %9.0g
ia82            float   %9.0g
ia83            float   %9.0g
r77             float   %9.0g
r78             float   %9.0g
r79             float   %9.0g
r80             float   %9.0g
r81             float   %9.0g
r82             float   %9.0g
r83             float   %9.0g
rating83        float   %9.0g
rating83c       float   %9.0g      bondrating
                                              Bond rating, 1983
dia             float   %9.0g
-------------------------------------------------------------------------------
Sorted by:

. summarize
```

```
    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
         s77 |         98     2399226     6835850      28188   5.50e+07
         s78 |         98     2757617     7812873      48432   6.32e+07
         s79 |         98     3084304     8191207     103004   6.63e+07
         s80 |         98     3081560     7295521     114562   5.77e+07
         s81 |         98     3328268     7815398     167239   6.27e+07
-------------+---------------------------------------------------------
         s82 |         98     3126689     7479808     115376   6.00e+07
         s83 |         98     3409835     9008834     108397   7.46e+07
         b77 |         98    1.019388    .2675541        .29       2.27
         b78 |         98       1.035    .2937677        .29       2.27
         b79 |         98    1.008265    .2601666        .29       2.27
-------------+---------------------------------------------------------
         b80 |         98    1.032245    .2380095        .29          2
         b81 |         98    1.015612    .2452773        .29       2.08
         b82 |         98    .9689796    .2139394        .29       1.65
         b83 |         98    .9932653    .2011348        .46       1.65
        is77 |         98    11.24923    5.615914  -16.54562   26.56383
-------------+---------------------------------------------------------
        is78 |         98    11.65585    4.528279   .5114942   26.84296
        is79 |         98    11.36975    4.527863    .045454   23.66122
        is80 |         98    11.04448    9.335074  -4.169284   88.73264
        is81 |         98    10.34562    4.951754   -2.06479   25.77528
        is82 |         98    7.204422    6.152187  -12.69882   24.89959
-------------+---------------------------------------------------------
        is83 |         98    7.846085    6.495875  -16.40544   26.55174
        ia77 |         98    14.95777    6.958497  -18.13673   37.67006
        ia78 |         98    15.53974    5.104227   1.188427   29.87578
        ia79 |         98    15.48429    5.302939   .0836498   28.42293
        ia80 |         98     13.8006    6.085422  -6.350523   29.75574
-------------+---------------------------------------------------------
        ia81 |         98    13.82875    5.952011  -2.480706    30.5371
        ia82 |         98    9.407202    7.306611  -12.54386   32.30307
        ia83 |         98    10.11473    7.441946  -13.08016   30.74564
         r77 |         98     2.34113    1.874804          0          6
         r78 |         98    2.419951    1.911573          0          6
-------------+---------------------------------------------------------
         r79 |         98    2.373979    1.912279          0          6
         r80 |         98    2.315973    1.855837          0          6
         r81 |         98    2.399914    1.841927          0          6
         r82 |         98    2.342588    1.851536          0          6
         r83 |         98    2.391481    1.850125          0          6
-------------+---------------------------------------------------------
    rating83 |         98    2.336735    1.787378          0          6
   rating83c |         98    3.479592     1.17736          2          5
         dia |         98    .7075242    4.711211  -10.79014   20.05367

. tabulate rating83c

       Bond |
    rating, |
       1983 |      Freq.     Percent        Cum.
------------+-----------------------------------
     BA_B_C |         26       26.53       26.53
        BAA |         28       28.57       55.10
```

```
       AA_A |         15       15.31       70.41
        AAA |         29       29.59      100.00
------------+-----------------------------------
      Total |         98      100.00

.
. ologit rating83c ia83 dia, nolog

Ordered logistic regression                     Number of obs     =         98
                                                LR chi2(2)        =      11.54
                                                Prob > chi2       =     0.0031
Log likelihood = -127.27146                     Pseudo R2         =     0.0434

------------------------------------------------------------------------------
   rating83c |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        ia83 |   .0939166   .0296196     3.17   0.002     .0358633    .1519699
         dia |  -.0866925   .0449789    -1.93   0.054    -.1748496    .0014646
-------------+----------------------------------------------------------------
       /cut1 |  -.1853053   .3571432                     -.8852932    .5146826
       /cut2 |   1.185726   .3882099                      .4248488    1.946604
       /cut3 |   1.908412   .4164896                      1.092108    2.724717
------------------------------------------------------------------------------

.
. predict spBA_B_C spBAA spAA_A spAAA
(option pr assumed; predicted probabilities)

. summarize spAAA, mean

. list sp* rating83c if spAAA == r(max)

     +-------------------------------------------------------+
     | spBA_B_C      spBAA     spAA_A      spAAA   rati~83c |
     |-------------------------------------------------------|
 31. | .0388714   .0985567   .1096733   .7528986        AAA |
     +-------------------------------------------------------+

.
. summarize spBA_B_C, mean

. list sp* rating83c if spBA_B_C == r(max)

     +-------------------------------------------------------+
     | spBA_B_C      spBAA     spAA_A      spAAA   rati~83c |
     |-------------------------------------------------------|
 67. | .7158453   .1926148   .0449056   .0466343        AAA |
     +-------------------------------------------------------+
```

10.3 TRUNCATED REGRESSION & TOBIT MODELS

10.3.1 *Truncation*

```
. use laborsub.. describe
```

```
Contains data from laborsub.dta
  obs:           250
 vars:             6                          25 Sep 2004 18:36
 size:         1,750
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
lfp             byte    %9.0g                 1 if woman worked in 1975
whrs            int     %9.0g                 Wife's hours of work
kl6             byte    %9.0g                 # of children younger than 6
k618            byte    %9.0g                 # of children between 6 and 18
wa              byte    %9.0g                 Wife's age
we              byte    %9.0g                 Wife's educational attainment
-------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
         lfp |        250          .6    .4908807          0          1
        whrs |        250      799.84    915.6035          0       4950
         kl6 |        250        .236    .5112234          0          3
        k618 |        250       1.364    1.370774          0          8
          wa |        250       42.92    8.426483         30         60
-------------+--------------------------------------------------------
          we |        250      12.352    2.164912          5         17

.
. regress whrs  kl6 k618 wa we if whrs > 0

      Source |       SS           df       MS      Number of obs   =       150
-------------+----------------------------------   F(4, 145)       =      2.80
       Model |  7326995.15         4  1831748.79   Prob > F        =    0.0281
    Residual |  94793104.2       145  653745.546   R-squared       =    0.0717
-------------+----------------------------------   Adj R-squared   =    0.0461
       Total |   102120099       149  685369.794   Root MSE        =    808.55

------------------------------------------------------------------------------
        whrs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         kl6 |  -421.4822   167.9734    -2.51   0.013    -753.4748   -89.48953
        k618 |  -104.4571   54.18616    -1.93   0.056    -211.5538    2.639668
          wa |  -4.784917   9.690502    -0.49   0.622     -23.9378    14.36797
          we |   9.353195   31.23793     0.30   0.765    -52.38731     71.0937
       _cons |   1629.817   615.1301     2.65   0.009     414.0371    2845.597
------------------------------------------------------------------------------

.
. truncreg whrs  kl6 k618 wa we, ll(0) nolog
(note: 100 obs. truncated)

Truncated regression
Limit:   lower =          0                     Number of obs     =        150
         upper =       +inf                     Wald chi2(4)      =      10.05
```

```
Log likelihood = -1200.9157                     Prob > chi2       =     0.0395

------------------------------------------------------------------------------
        whrs |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         kl6 |  -803.0042   321.3614    -2.50   0.012    -1432.861   -173.1474
        k618 |   -172.875   88.72898    -1.95   0.051    -346.7806    1.030579
          wa |  -8.821123   14.36848    -0.61   0.539    -36.98283    19.34059
          we |   16.52873   46.50375     0.36   0.722    -74.61695    107.6744
       _cons |    1586.26    912.355     1.74   0.082    -201.9233    3374.442
-------------+----------------------------------------------------------------
      /sigma |   983.7262   94.44303    10.42   0.000     798.6213    1168.831
------------------------------------------------------------------------------
```

10.3.2 *Censoring*

```
. use womenwk.. describe

Contains data from womenwk.dta
  obs:         2,000
 vars:            15                          9 Nov 2004 20:23
 size:       134,000
-------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------
c1              double  %10.0g
c2              double  %10.0g
u               double  %10.0g
v               double  %10.0g
county          float   %9.0g
age             int     %8.0g
education       int     %8.0g
married         byte    %8.0g
children        int     %8.0g
select          float   %9.0g
wagefull        float   %9.0g
wage            float   %9.0g
lw              float   %9.0g
work            float   %9.0g
lwf             float   %9.0g
-------------------------------------------------------------------------------
Sorted by:

. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
          c1 |      2,000   -.0023069    .9880571  -3.500514   3.614182
          c2 |      2,000   -.0077596    1.006025  -3.410111   3.423961
           u |      2,000   -.0011535    .4940286  -1.750257   1.807091
           v |      2,000   -.0071367           1  -3.954782   3.229851
      county |      2,000         4.5       2.873          0          9
-------------+--------------------------------------------------------
```

```
         age |      2,000      36.208     8.28656         20         59
   education |      2,000      13.084    3.045912         10         20
     married |      2,000       .6705    .4701492          0          1
    children |      2,000      1.6445    1.398963          0          5
      select |      2,000    35.78556    14.98163  -14.45688   89.63869
-------------+---------------------------------------------------------
    wagefull |      2,000    21.31176    7.012038  -1.680425   45.80979
        wage |      1,343    23.69217    6.305374    5.88497   45.80979
          lw |      1,343    3.126703    .2865111   1.772402   3.824498
        work |      2,000       .6715    .4697852          0          1
         lwf |      2,000    2.099581    1.487519          0   3.824498

.
. regress lwf age married children education

      Source |       SS           df       MS      Number of obs   =     2,000
-------------+----------------------------------   F(4, 1995)      =    134.21
       Model |  937.873188         4  234.468297   Prob > F        =    0.0000
    Residual |  3485.34135     1,995  1.74703827   R-squared       =    0.2120
-------------+----------------------------------   Adj R-squared   =    0.2105
       Total |  4423.21454     1,999  2.21271363   Root MSE        =    1.3218

------------------------------------------------------------------------------
         lwf |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .0363624    .003862     9.42   0.000     .0287885    .0439362
     married |   .3188214   .0690834     4.62   0.000     .1833381    .4543046
    children |   .3305009   .0213143    15.51   0.000     .2887004    .3723015
   education |   .0843345   .0102295     8.24   0.000     .0642729    .1043961
       _cons |  -1.077738   .1703218    -6.33   0.000    -1.411765   -.7437105
------------------------------------------------------------------------------

.
. tobit lwf age married children education, ll(0)

Refining starting values:

Grid node 0:   log likelihood = -3563.7251

Fitting full model:

Iteration 0:   log likelihood = -3563.7251
Iteration 1:   log likelihood = -3368.4259
Iteration 2:   log likelihood = -3350.1512
Iteration 3:   log likelihood = -3349.9689
Iteration 4:   log likelihood = -3349.9685
Iteration 5:   log likelihood = -3349.9685

Tobit regression                                Number of obs     =      2,000
                                                  Uncensored     =      1,343
Limits: lower = 0                                 Left-censored  =        657
        upper = +inf                              Right-censored =          0

                                                LR chi2(4)        =     461.85
                                                Prob > chi2       =     0.0000
Log likelihood = -3349.9685                     Pseudo R2         =     0.0645
```

```
------------------------------------------------------------------------------
         lwf |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |    .052157   .0057457     9.08   0.000     .0408888    .0634252
     married |   .4841801   .1035191     4.68   0.000     .2811633     .687197
    children |   .4860021   .0317055    15.33   0.000     .4238228    .5481814
   education |   .1149492   .0150913     7.62   0.000     .0853528    .1445455
       _cons |  -2.807696   .2632573   -10.67   0.000    -3.323984   -2.291408
-------------+----------------------------------------------------------------
   var(e.lwf)|   3.507421   .1498785                      3.225466    3.814024
------------------------------------------------------------------------------

. mfx compute, predict(pr(0,.))

Marginal effects after tobit
      y  = Pr(lwf>0) (predict, pr(0,.))
         =  .81920975
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     age |   .0073278      .00083    8.84   0.000   .005703  .008952    36.208
 married*|   .0706994      .01576    4.48   0.000   .039803  .101596     .6705
children |   .0682813      .00479   14.26   0.000   .058899  .077663    1.6445
educat~n |   .0161499      .00216    7.48   0.000   .011918  .020382    13.084
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1

. mfx compute, predict(e(0,.))

Marginal effects after tobit
      y  = E(lwf|lwf>0) (predict, e(0,.))
         =  2.3102021
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     age |   .0314922      .00347    9.08   0.000   .024695   .03829    36.208
 married*|   .2861047      .05982    4.78   0.000   .168855  .403355     .6705
children |   .2934463      .01908   15.38   0.000   .256041  .330852    1.6445
educat~n |   .0694059      .00912    7.61   0.000   .051531  .087281    13.084
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

10.4 INCIDENTAL TRUNCATION & SAMPLE SELECTION MODELS

```
. use womenwk..
. heckman lw education age children,  select(age married children education) no
> log

Heckman selection model                         Number of obs     =      2,000
(regression model with sample selection)              Selected    =      1,343
                                                      Nonselected =        657

                                                Wald chi2(3)      =     454.78
Log likelihood = -1052.857                      Prob > chi2       =     0.0000
```

```
------------------------------------------------------------------------------
          lw |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lw           |
   education |   .0397189   .0024525    16.20   0.000     .0349121    .0445256
         age |   .0075872   .0009748     7.78   0.000     .0056767    .0094977
    children |  -.0180477   .0064544    -2.80   0.005    -.0306981   -.0053973
       _cons |   2.305499   .0653024    35.30   0.000     2.177509     2.43349
-------------+----------------------------------------------------------------
select       |
         age |   .0350233   .0042344     8.27   0.000     .0267241    .0433225
     married |   .4547724   .0735876     6.18   0.000     .3105434    .5990014
    children |   .4538372   .0288398    15.74   0.000     .3973122    .5103621
   education |   .0565136   .0110025     5.14   0.000     .0349492    .0780781
       _cons |  -2.478055   .1927823   -12.85   0.000    -2.855901   -2.100208
-------------+----------------------------------------------------------------
     /athrho |   .3377674   .1152251     2.93   0.003     .1119304    .5636045
    /lnsigma |  -1.375543   .0246873   -55.72   0.000    -1.423929   -1.327156
-------------+----------------------------------------------------------------
         rho |   .3254828   .1030183                      .1114653    .5106469
       sigma |   .2527024   .0062385                      .2407662    .2652304
      lambda |   .0822503   .0273475                      .0286501    .1358505
------------------------------------------------------------------------------
LR test of indep. eqns. (rho = 0):   chi2(1) =     5.53   Prob > chi2 = 0.0187

.
. heckman lw education age children,  select(age married children education) tw
> ostep

Heckman selection model -- two-step estimates   Number of obs     =      2,000
(regression model with sample selection)              Selected    =      1,343
                                                      Nonselected =        657

                                                Wald chi2(3)      =     405.68
                                                Prob > chi2       =     0.0000

------------------------------------------------------------------------------
          lw |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lw           |
   education |   .0427067    .003106    13.75   0.000     .0366191    .0487944
         age |    .009322   .0014343     6.50   0.000     .0065108    .0121333
    children |  -.0019549   .0115202    -0.17   0.865    -.0245341    .0206242
       _cons |   2.124787   .1249789    17.00   0.000     1.879833    2.369741
-------------+----------------------------------------------------------------
select       |
         age |   .0347211   .0042293     8.21   0.000     .0264318    .0430105
     married |   .4308575    .074208     5.81   0.000     .2854125    .5763025
    children |   .4473249   .0287417    15.56   0.000     .3909922    .5036576
   education |   .0583645   .0109742     5.32   0.000     .0368555    .0798735
       _cons |  -2.467365   .1925635   -12.81   0.000    -2.844782   -2.089948
-------------+----------------------------------------------------------------
/mills       |
      lambda |   .1822815   .0638285     2.86   0.004       .05718     .307383
-------------+----------------------------------------------------------------
         rho |    0.66698
```

```
       sigma |  .27329216
------------------------------------------------------------------------------
```

10.5 BIVARIATE PROBIT & PROBIT WITH SELECTION

```
. use hmda..
. replace fanfred = . if deny
(285 real changes made, 285 to missing)

. rename s6 loanamt

. rename vr vacancy

. rename mi med_income

. rename s50 appr_value

. rename s17 appl_income

. replace appl_income = appl_income/1000
(2,379 real changes made)

. rename s46 debt_inc_r

.
. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
         seq |      2,380    2328.934    1293.337          2       4509
          s3 |      2,380           1           0          1          1
          s4 |      2,380           1           0          1          1
          s5 |      2,380    1.036555    .2027758          1          3
     loanamt |      2,380    139.1353    83.42097          2        980
-------------+---------------------------------------------------------
          s7 |      2,380    1.268908    .6605115          1          3
          s9 |      2,380        1120           0       1120       1120
         s11 |      2,380    .1743697    .3795069          0          1
         s13 |      2,380    4.715126    .6991424          3          5
         s14 |      2,379    5.702816    1.580592          1          8
-------------+---------------------------------------------------------
         s15 |      2,380    1.223109    .4342082          1          3
         s16 |      2,379    2.513241    .9831064          1          8
 appl_income |      2,380     13.9406    116.9485          0   999.9994
         s18 |      2,265    1.954967    3.044967          0          9
        s19a |          0
-------------+---------------------------------------------------------
        s19b |          0
        s19c |          0
        s19d |          0
         s20 |      2,380    1261.521    35488.59          1   999999.4
        s23a |          0
-------------+---------------------------------------------------------
        s24a |      2,380    .7605042    1.104747          0          8
```

```
        s25a |      2,380    19758.32    139160.4          0   999999.4
        s26a |      2,380    22275.29    147586.7          0   999999.4
        s27a |      2,380    .1163866    .3207553          0          1
        s30a |      2,380    4332.712    4663.801          0      81000
-------------+---------------------------------------------------------
        s30c |      2,380    1360.359     2130.56          0      41667
        s31a |      2,380    4914.016    5162.458          0      81000
        s31c |      2,380     1471.81    2358.868          0      41667
         s32 |      2,380    1457.293    854.9721          0      10798
         s33 |      2,380    1870.239    40962.55          0   999999.4
-------------+---------------------------------------------------------
         s34 |      2,380    4.507271     87.8796          0       3908
         s35 |      2,380    5134.612    70836.87          0   999999.4
         s39 |      2,380    3782.993    61390.39          0   999999.4
         s40 |      2,380        1.75    23.60479          0        666
         s41 |      2,380    433.6915    20497.71          0   999999.4
-------------+---------------------------------------------------------
         s42 |      2,380    1.721008    .5372816          1          4
         s43 |      2,380    2.116387    1.666721          1          6
         s44 |      2,380    .0735294    .2610584          0          1
         s45 |      2,380    25.53461    9.665561          0        300
  debt_inc_r |      2,380    33.08136    10.72573          0        300
-------------+---------------------------------------------------------
         s47 |      2,380    1.670588    .4736616          1          3
         s48 |      2,380    2022.587    40956.14          6   999999.4
         s49 |          0
  appr_value |      2,380    198.5426    152.9863         25       4316
         s51 |      2,380    1.711765    .4530364          1          2
-------------+---------------------------------------------------------
         s52 |      2,380    .2256303    .4180845          0          1
         s53 |      2,380    .0201681    .1406045          0          1
         s54 |          0
         s55 |      2,380    .0294118    .1689932          0          1
         s56 |      2,380     .047479    .2127058          0          1
-------------+---------------------------------------------------------
         s57 |      2,380    102102.5    302843.7          0   999999.4
        netw |      2,380    253.0412    1072.576      -7919      28023
        uria |      2,380    3.774496    2.027062        1.8       10.6
       rtdum |      2,380    .0726891      .25968          0          1
          bd |      2,380     .444958    .4970656          0          1
-------------+---------------------------------------------------------
  med_income |      2,380    .8294118    .3762278          0          1
         old |      2,380    .4630252    .5054334          0          2
     vacancy |      2,380    .4365546    .4960626          0          1
      school |      2,380    9679.206    97847.79          5   999999.4
       chval |      2,380    6993.166     81710.9  -8.333333   999999.4
-------------+---------------------------------------------------------
     dnotown |      2,380    .0336134    .1802699          0          1
       dprop |      2,380           0           0          0          0
        deny |      2,380    .1197479    .3247347          0          1
     fanfred |      2,095    .3331742    .4714608          0          1
     approve |      2,380    .8802521    .3247347          0          1
-------------+---------------------------------------------------------
       black |      2,380     .142437    .3495712          0          1

.
. heckprob fanfred loanamt vacancy med_income appr_value, select(approve = blac
```

```
> k appl_income debt_inc_r) nolog

Probit model with sample selection              Number of obs     =      2,380
                                                      Selected    =      2,095
                                                      Nonselected =        285

                                                Wald chi2(4)      =      80.69
Log likelihood = -2063.066                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
fanfred      |
     loanamt |  -.0026434   .0008029    -3.29   0.001    -.0042169   -.0010698
     vacancy |  -.2163307   .0609798    -3.55   0.000    -.3358489   -.0968125
  med_income |   .2671341   .0893349     2.99   0.003     .0920409    .4422273
  appr_value |  -.0014358   .0005099    -2.82   0.005    -.0024351   -.0004364
       _cons |   .1684824   .1182055     1.43   0.154    -.0631961    .4001608
-------------+----------------------------------------------------------------
approve      |
       black |  -.7343534    .081858    -8.97   0.000    -.8947921   -.5739148
 appl_income |  -.0006596    .000236    -2.80   0.005    -.0011221   -.0001971
  debt_inc_r |  -.0262367   .0036441    -7.20   0.000    -.0333791   -.0190944
       _cons |   2.236424   .1319308    16.95   0.000     1.977845    2.495004
-------------+----------------------------------------------------------------
     /athrho |  -.6006599   .2712535    -2.21   0.027    -1.132307   -.0690128
-------------+----------------------------------------------------------------
         rho |   -.537519   .1928812                     -.8118074   -.0689034
------------------------------------------------------------------------------
LR test of indep. eqns. (rho = 0):   chi2(1) =     4.99   Prob > chi2 = 0.0255
```

10.5.1 *Binomial Probit with Selection*

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