ADVANCED ECONOMETRICS I

Practice Exercises (1/2)

Instructor: Joaquim J. S. Ramalho

E.mail: jjsro@iscte-iul.pt

Personal Website: http://home.iscte-iul.pt/~jjsro

Office: D5.10

Course Website: https://jjsramalho.wixsite.com/advecoi

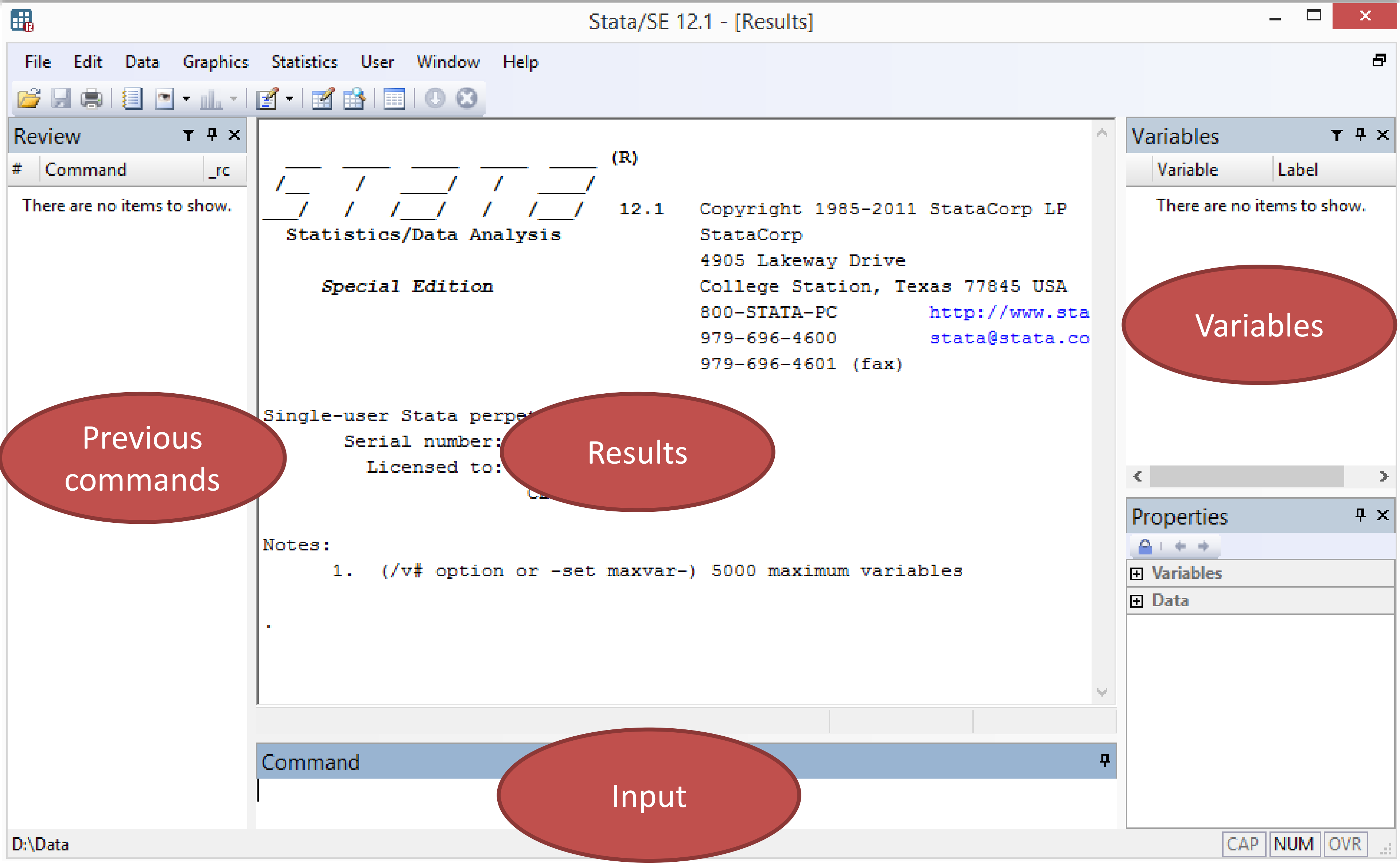
Fénix: https://fenix.iscte-iul.pt/disciplinas/03089

Using Stata

How to run commands:

- Use the menu
  - Useful when the command name is not known
- Write the command line
  - Standard approach
- Run a *do* file (contains several command lines)
  - Ideal for running a series of commands
  - Allows implementation of methods not available in Stata

Stata – Main Windows



Stata – Main Menu

File

- Open – open dataset
- Save – save dataset
- Do – run a *do* file
- Log – register everything that you type and any output that appears in the Results window in a *smcl* file (only accessible in Stata) ou *log* (plain text that can be read by any text processor)
    - Begin – opens a log file
    - Close – closes the log file
    - Suspend – suspends logging
    - Resume – resumes logging

Stata – Main Menu (cont.)

File (cont.)

- Import – reads non-Stata data (ASCII, Excel, etc.)
- Export – export Stata data to other formats

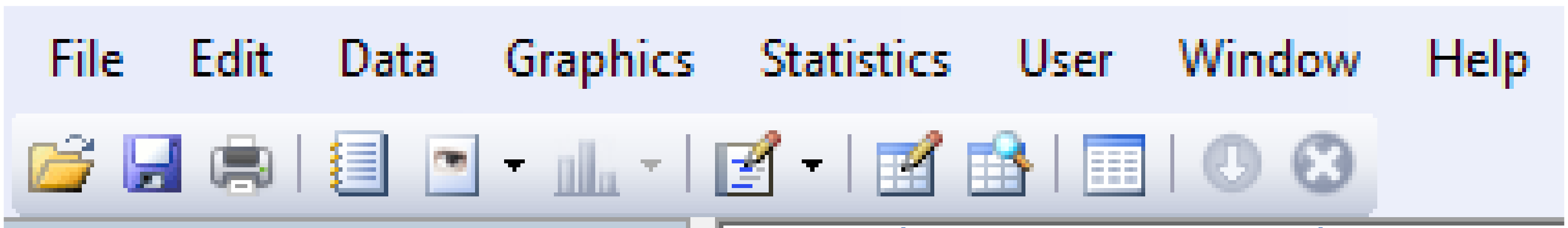
Window

- Data Editor – brings up a spreadsheet-style editor for entering new data and editing existing data
- Do-file Editor
  - New Do-File Editor – starts a new text editor of *do* files

Help

- Search – search Stata documentation and other resources
- Stata command – displays help information about the specified command

Stata – Main Shortcuts



Open

Save

Log

New Do-File Editor

Data Editor

Stops the current command execution

Stata – Some Commands

describe [*varlist*]

- Produces a summary of the dataset

summarize [*varlist*] [, detail]

- Displays a variety of univariate summary statistics

generate *newvar* = *formula*

- Creates a new variable

replace *varname* = *formula* [if *expression*] [in #/#]

- Replaces contents of an existing variable

drop [*varlist*] [if *expression*] [in #/#]

- Drops variables or observations

Stata – Some Other Commands

keep [*varlist*] [if *expression*] [in #/#]

- Keeps variables or observations

display *scalar_expression*

- Displays strings and values of scalar expressions

scalar *scalar_name = expression*

- Defines a scalar variable

return list

- Returns results for general commands, stored in *r()*

ereturn list

- Returns results for estimation commands, stored in *e()*

Stata – Others

Missing data:

- .

Conditions:

- Equality: ==
- Different: !=
- Or: |
- And: &

Estimates:

- predict [, *options*] $\rightarrow \hat{Y}, \hat{u}, X\hat{\beta}, \ldots$

Illustration 1 – Question 1

```
. describe

  obs:        32,226
 vars:            18
 size:     1,740,204
-------------------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-------------------------------------------------------------------------------------------
id              int     %8.0g                 Firm id
YEAR            int     %8.0g                 Year
LEV_ST1         float   %9.0g                 Short-term debt / (STD+LTD+Equity)
LEV_LT1         float   %9.0g                 Long-term debt / (STD+LTD+Equity)
LEV1            float   %9.0g                 Total debt / (STD+LTD+Equity)
COLLAT1         float   %9.0g                 Tangible assets / Total assets
COLLAT2         float   %9.0g                 (Tangible assets + Stock) / Total assets
SIZE1           float   %9.0g                 Log(Total assets)
SIZE2           float   %9.0g                 Log(Sales)
PROF1           float   %9.0g                 EBIT / Total assets
PROF2           float   %9.0g                 EBITDA / Total assets
GROWTH1         float   %9.0g                 Sales growth rate
GROWTH2         float   %9.0g                 Total assets growth rate
AGE             int     %8.0g                 YEAR - Foundation year
LE              byte    %8.0g                 =1 if large firm
MicE            byte    %8.0g                 =1 if micro firm
SE              byte    %8.0g                 =1 if small firm
MedE            byte    %8.0g                 =1 if medium firm
-------------------------------------------------------------------------------------------
```

Illustration 1 – Question 2

```
. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
          id |      32226     2714.09    1597.178          1       5514
        YEAR |      32226     1998.01    1.989032       1995       2001
     LEV_ST1 |      32226    .1583845    .2185988          0   .9997105
     LEV_LT1 |      32226    .0768912    .1678684          0   .9982489
        LEV1 |      32226    .2352757    .2589438          0   .9997105
-------------+---------------------------------------------------------
     COLLAT1 |      32226    .3175925      .22441          0   .9982307
     COLLAT2 |      32226    .4127954    .2339423          0   1.081665
       SIZE1 |      32226    13.66189    1.922785   4.976734   22.38044
       SIZE2 |      32226    13.76888    1.851772   5.594711   22.44638
       PROF1 |      32226    .0671496    .1138881   -.822547   10.11724
-------------+---------------------------------------------------------
       PROF2 |      32226    .1477722      .15208   .0000158   12.47599
     GROWTH1 |      32226    27.98725    559.0894  -99.89224   73055.81
     GROWTH2 |      32226    14.69437    68.35662  -94.02072   7308.115
         AGE |      32226    20.25119     15.6708          1        212
          LE |      32226    .0596413    .2368247          0          1
-------------+---------------------------------------------------------
        MicE |      32226    .3063986    .4610044          0          1
          SE |      32226    .4156892    .4928481          0          1
        MedE |      32226     .218271    .4130787          0          1
```

Illustration 1 – Question 3

```
. gen GROUPS="1-Micro" if MicE==1
. replace GROUPS="2-Small" if SE==1
. replace GROUPS="3-Medium" if MedE==1
. replace GROUPS="4-Large" if LE==1

. tabulate GROUPS

     GROUPS |      Freq.     Percent        Cum.
------------+-----------------------------------
    1-Micro |      9,874       30.64       30.64
    2-Small |     13,396       41.57       72.21
   3-Medium |      7,034       21.83       94.04
    4-Large |      1,922        5.96      100.00
------------+-----------------------------------
      Total |     32,226      100.00
```

Illustration 1 – Question 4

```
. tabulate GROUPS YEAR

           |                        Ano
    GROUPS |      1995       1996       1997       1998 |     Total
-----------+--------------------------------------------+----------
   1-Micro |     1,418      1,441      1,414      1,431 |     9,874
   2-Small |     1,845      1,893      1,907      1,946 |    13,396
  3-Medium |       967        968      1,006      1,030 |     7,034
   4-Large |       279        267        271        277 |     1,922
-----------+--------------------------------------------+----------
     Total |     4,509      4,569      4,598      4,684 |    32,226


           |                  Ano
    GROUPS |      1999       2000       2001 |     Total
-----------+---------------------------------+----------
   1-Micro |     1,446      1,392      1,332 |     9,874
   2-Small |     1,951      1,950      1,904 |    13,396
  3-Medium |     1,024      1,019      1,020 |     7,034
   4-Large |       271        283        274 |     1,922
-----------+---------------------------------+----------
     Total |     4,692      4,644      4,530 |    32,226
```

Illustration 1 – Question 5

```
. table GROUPS, contents(mean LEV_ST1 mean LEV_LT1 mean
LEV1)

--------------------------------------------------------
GROUPS     | mean(LEV_ST1)  mean(LEV_LT1)     mean(LEV1)
-----------+--------------------------------------------
   1-Micro |       .1288624       .0417675      .1706299
   2-Small |       .1721035       .0750359      .2471394
  3-Medium |       .1752302       .1147087       .289939
   4-Large |       .1527809       .1318627      .2846436
--------------------------------------------------------
```

Illustration 1 – Question 6.1

```
. keep if YEAR==1999
(27534 observations deleted)

. regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE

      Source |       SS       df       MS              Number of obs =    4692
-------------+------------------------------           F(  8,  4683) =   30.72
       Model |  7.30759869     8  .913449837           Prob > F      =  0.0000
    Residual |  139.231012  4683  .029731158           R-squared     =  0.0499
-------------+------------------------------           Adj R-squared =  0.0482
       Total |   146.53861  4691  .031238246           Root MSE      =  .17243

------------------------------------------------------------------------------
     LEV_LT1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       SIZE2 |   .0181417   .0024457     7.42   0.000     .0133469    .0229364
     COLLAT2 |   .0218571   .0111495     1.96   0.050    -1.11e-06    .0437153
       PROF1 |  -.1934835   .0280368    -6.90   0.000    -.2484489   -.1385182
     GROWTH2 |   .0001606   .0000709     2.26   0.024     .0000216    .0002997
         AGE |  -.0001155   .0001712    -0.67   0.500     -.000451    .0002201
          SE |  -.0035225   .0073927    -0.48   0.634    -.0180157    .0109707
        MedE |     .01049   .0112029     0.94   0.349    -.0114729    .0324528
          LE |  -.0213549   .0177432    -1.20   0.229    -.0561399    .0134301
       _cons |   -.163565   .0306424    -5.34   0.000    -.2236385   -.1034915
------------------------------------------------------------------------------
```

Illustration 1 – Question 6.2

Explanatory variables which are significant at the 5% level:

- $SIZE2$, $COLLAT2$, $PROF1$ and $GROWTH2$

Partial effects:

- When sales increase 1%, the proportion of long-term debt in the firm's capital structure increases 0.018 p.p.
- When the proportion of collateral in total assets increases 1 percentage point (pp), the proportion of long-term debt in the firm's capital structure increases 0.022 pp
- When profitability increases 1 pp, the proportion of long-term debt in the firm's capital structure decreases 0.193 pp
- When the growth rate of total assets increases 1 pp, the proportion of long-term debt in the firm's capital structure increases 0.0002 pp
- Age and size-based group dummies do not influence the proportion of long-term debt in the firm's capital structure

Illustration 1 – Question 6.2 (cont.)

Theoretical arguments:

- Positive effects:
  - $SIZE2$: larger firms tend to be more diversified, so their probability of bankruptcy is relatively smaller and it is easier for them to raise debt
  - $COLLAT2$: firms with a greater percentage of their total assets composed of tangible assets have a higher capacity for raising debt since, in case of liquidation, these assets keep their value
  - $GROWTH2$: Firms with more investment opportunities borrow more since their probability of outrunning internally generated funds is larger
- Negative effects:
  - $PROF1$: The more profitable the firm, the greater the availability of internal capital, the less the need for external funds

Illustration 1 – Question 7.1

Model:

$$LEV\_LT1 = \beta_0 + \beta_1 SIZE2 + \beta_2 COLLAT2 + \beta_3 PROF1 + \beta_4 GROWTH2 + \beta_5 AGE + \beta_6 (SE * PROF1) + \beta_7 (MedE * PROF1) + \beta_8 (LE * PROF1) + v$$

Effects of firm profitability:

- Micro firms: β_3
- Small firms: $\beta_3 + \beta_6$
- Medium firms: $\beta_3 + \beta_7$
- Large firms: $\beta_3 + \beta_8$

Null hypotheses:

	Small	Medium	Large
Micro	$\beta_6 = 0$	$\beta_7 = 0$	$\beta_8 = 0$
Small		$\beta_6 = \beta_7$	$\beta_6 = \beta_8$
Medium			$\beta_7 = \beta_9$

Illustration 1 – Question 7.1 (cont.)

```
. gen PROF_SE=PROF1*SE
. gen PROF_MedE=PROF1*MedE
. gen PROF_LE=PROF1*LE
. regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE PROF_SE PROF_MedE PROF_LE

      Source |       SS       df       MS              Number of obs =    4692
-------------+------------------------------           F(  8,  4683) =   32.28
       Model |  7.65730862     8  .957163578           Prob > F      =  0.0000
    Residual |  138.881302  4683  .029656481           R-squared     =  0.0523
-------------+------------------------------           Adj R-squared =  0.0506
       Total |   146.53861  4691  .031238246           Root MSE      =  .17221

------------------------------------------------------------------------------
     LEV_LT1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       SIZE2 |   .0214744   .0016573    12.96   0.000     .0182253    .0247236
     COLLAT2 |   .0246972   .0109637     2.25   0.024     .0032032    .0461912
       PROF1 |  -.0956589   .0365451    -2.62   0.009    -.1673044   -.0240134
     GROWTH2 |   .0001575   .0000708     2.22   0.026     .0000187    .0002963
         AGE |  -.0001012   .0001687    -0.60   0.548    -.0004319    .0002294
     PROF_SE |  -.1701758   .0528889    -3.22   0.001     -.273863   -.0664886
   PROF_MedE |  -.2279809   .0747108    -3.05   0.002    -.3744492   -.0815125
     PROF_LE |  -.4960758   .1385872    -3.58   0.000     -.767772   -.2243797
       _cons |  -.2091211   .0228067    -9.17   0.000    -.2538331   -.1644091
------------------------------------------------------------------------------
```

Illustration 1 – Question 7.1 (cont.)

Effects of firm profitability:

- When profitability increases 1 percentage point, the proportion of long-term debt in the firm's capital structure decreases, on average:
  - 0.096 p.p. (micro firms)
  - 0.266 p.p. (small firms) → display _b[PROF1]+_b[PROF_SE]
  - 0.324 p.p. (medium firms) → display _b[PROF1]+_b[PROF_MedE]
  - 0.592 p.p. (large firms) → display _b[PROF1]+_b[PROF_LE]

Illustration 1 – Question 7.1 (cont.)

Profitability effects differ significantly across groups?

```
. test PROF_SE=PROF_MedE

 ( 1)  PROF_SE - PROF_MedE = 0

       F(  1,  4683) =    0.62
            Prob > F =    0.4295

. test PROF_SE=PROF_LE

 ( 1)  PROF_SE - PROF_LE = 0

       F(  1,  4683) =    5.80
            Prob > F =    0.0161

. test PROF_MedE=PROF_LE

 ( 1)  PROF_MedE - PROF_LE = 0

       F(  1,  4683) =    3.80
            Prob > F =    0.0514
```

(p-values)	Small	Medium	Large
Micro	0.001***	0.002***	0.000***
Small		0.430	0.016**
Medium			0.051*

Illustration 1 – Question 7.2

Model:

$$
\begin{aligned}
&LEV\_LT1 \\
&= \beta_0 + \beta_1 SIZE2 + \beta_2 COLLAT2 + \beta_3 PROF1 + \beta_4 GROWTH2 + \beta_5 AGE \\
&+ \beta_6 LE + \beta_7 (LE * SIZE2) + \beta_8 (LE * COLLAT2) + \beta_9 (LE * PROF1) \\
&+ \beta_{10} (LE * GROWTH2) + \beta_{11} (LE * AGE) + w
\end{aligned}
$$

Null hypotheses:

- $H_0: \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$ (no structural break)

```
. gen SIZE_LE=SIZE2*LE
. gen COLLAT_LE=COLLAT2*LE
. gen GROWTH_LE=GROWTH2*LE
. gen AGE_LE=AGE*LE
```

Illustration 1 – Question 7.2 (cont.)

```
. regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE LE SIZE_LE COLLAT_LE PROF_LE GROWTH_LE
AGE_LE

      Source |       SS       df       MS              Number of obs =    4692
-------------+------------------------------           F( 11,  4680) =   23.18
       Model |  7.57031284    11  .688210258           Prob > F      =  0.0000
    Residual |  138.968298  4680  .029694081           R-squared     =  0.0517
-------------+------------------------------           Adj R-squared =  0.0494
       Total |   146.53861  4691  .031238246           Root MSE      =  .17232

------------------------------------------------------------------------------
     LEV_LT1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       SIZE2 |   .0201386   .0016462    12.23   0.000     .0169112    .0233659
     COLLAT2 |   .0183107     .01121     1.63   0.102    -.0036663    .0402876
       PROF1 |  -.1875618   .0284758    -6.59   0.000    -.2433877   -.1317359
     GROWTH2 |   .0001402   .0000714     1.96   0.050     2.21e-07    .0002801
         AGE |  -.0000991   .0001836    -0.54   0.589    -.0004591    .0002609
          LE |   .1111638   .1700823     0.65   0.513    -.2222776    .4446052
     SIZE_LE |  -.0112264   .0097198    -1.16   0.248    -.0302819     .007829
   COLLAT_LE |   .1028742   .0535543     1.92   0.055    -.0021174    .2078658
     PROF_LE |  -.1782237   .1625401    -1.10   0.273    -.4968789    .1404315
   GROWTH_LE |   .0012962   .0005855     2.21   0.027     .0001484    .0024441
      AGE_LE |    .000248   .0004729     0.52   0.600    -.0006792    .0011752
       _cons |   -.188839   .0224668    -8.41   0.000    -.2328845   -.1447935
------------------------------------------------------------------------------
```

Illustration 1 – Question 7.2 (cont.)

```
. test LE SIZE_LE COLLAT_LE PROF_LE GROWTH_LE AGE_LE

 ( 1)  LE = 0
 ( 2)  SIZE_LE = 0
 ( 3)  COLLAT_LE = 0
 ( 4)  PROF_LE = 0
 ( 5)  GROWTH_LE = 0
 ( 6)  AGE_LE = 0

       F(   6,  4680) =    2.93
            Prob > F =    0.0075
```

The null hypothesis is rejected, which implies that is better to estimate separate models for each size-based group of firms or, equivalently, the model of the previous page, since:

(see the next page)

Illustration 1 – Question 7.2 (cont.)

```
. regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE if LE==0
(…)
------------------------------------------------------------------------------
     LEV_LT1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       SIZE2 |   .0201386   .0016489    12.21   0.000     .0169059    .0233713
     COLLAT2 |   .0183107   .0112285     1.63   0.103    -.0037029    .0403242
       PROF1 |  -.1875618   .0285227    -6.58   0.000    -.2434806    -.131643
     GROWTH2 |   .0001402   .0000715     1.96   0.050    -1.16e-08    .0002803
         AGE |  -.0000991   .0001839    -0.54   0.590    -.0004597    .0002615
       _cons |   -.188839   .0225038    -8.39   0.000    -.2329578   -.1447202
------------------------------------------------------------------------------
```

```
. regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE if LE==1
(…)
------------------------------------------------------------------------------
     LEV_LT1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       SIZE2 |   .0089121   .0093123     0.96   0.339    -.0094235    .0272478
     COLLAT2 |   .1211849   .0509079     2.38   0.018     .0209496    .2214202
       PROF1 |  -.3657855   .1555647    -2.35   0.019    -.6720856   -.0594854
     GROWTH2 |   .0014364   .0005649     2.54   0.012     .0003241    .0025487
         AGE |   .0001489   .0004237     0.35   0.726    -.0006853    .0009831
       _cons |  -.0776752   .1638915    -0.47   0.636    -.4003704      .24502
------------------------------------------------------------------------------
```

Illustration 1 – Questions 8.1-8.2

```
. quietly regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE


. estat ovtest

Ramsey RESET test using powers of the fitted values of LEV_LT1
       Ho:  model has no omitted variables
                F(3, 4680) =      5.74
                  Prob > F =      0.0006
```
→ Unsuitable model functional form

```
. estat hettest, rhs fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE

         F(8 , 4683)  =     9.27
         Prob > F     =   0.0000
```
→ Heteroskedastic model

Illustration 1 – Questions 8.1-8.2 (cont.)

RESET test – manual implementation

```
. predict XB
. gen XB2=XB^2
. gen XB3=XB^3
. gen XB4=XB^4
. quietly regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE XB2 XB3 XB4

. test XB2 XB3 XB4

 ( 1)  XB2 = 0
 ( 2)  XB3 = 0
 ( 3)  XB4 = 0

       F(  3,  4680) =    5.74
            Prob > F =    0.0006
```

Illustration 1 – Questions 8.1-8.2 (cont.)

BP test – manual implementation

```
. quietly regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE

. predict uhat, resid

. gen uhat2=uhat^2

. quietly regress uhat2 SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE

. test SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE

 ( 1)  SIZE2 = 0
 ( 2)  COLLAT2 = 0
 ( 3)  PROF1 = 0
 ( 4)  GROWTH2 = 0
 ( 5)  AGE = 0
 ( 6)  SE = 0
 ( 7)  MedE = 0
 ( 8)  LE = 0

       F(  8,  4683) =    9.27
            Prob > F =    0.0000
```

Illustration 1 – Question 8.3

```
. regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE, vce(robust)

Linear regression                               Number of obs     =      4,692
                                                F(8, 4683)        =      42.14
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0499
                                                Root MSE          =     .17243

------------------------------------------------------------------------------
             |               Robust
     LEV_LT1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       SIZE2 |   .0181417   .0024326     7.46   0.000     .0133726    .0229108
     COLLAT2 |   .0218571    .011979     1.82   0.068    -.0016274    .0453416
       PROF1 |  -.1934835   .0229661    -8.42   0.000    -.2385079   -.1484592
     GROWTH2 |   .0001606   .0000728     2.21   0.027      .000018    .0003033
         AGE |  -.0001155    .000165    -0.70   0.484     -.000439    .0002081
          SE |  -.0035225   .0079668    -0.44   0.658    -.0191412    .0120962
        MedE |     .01049   .0121353     0.86   0.387    -.0133008    .0342808
          LE |  -.0213549   .0182307    -1.17   0.242    -.0570957    .0143859
       _cons |   -.163565   .0278539    -5.87   0.000    -.2181718   -.1089582
------------------------------------------------------------------------------
```

Illustration 1 – Question 8.3 (cont.)

```
. regress LEV_LT1 SIZE2 COLLAT2 PROF1 GROWTH2 AGE SE MedE LE, vce(bootstrap,reps(500)
seed(111))
(…)
Linear regression                               Number of obs     =      4,692
                                                Replications      =        500
                                                Wald chi2(8)      =     366.03
                                                Prob > chi2       =     0.0000
                                                R-squared         =     0.0499
                                                Adj R-squared     =     0.0482
                                                Root MSE          =     0.1724

------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
     LEV_LT1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       SIZE2 |   .0181417   .0023948     7.58   0.000      .013448    .0228354
     COLLAT2 |   .0218571   .0114746     1.90   0.057    -.0006327    .0443469
       PROF1 |  -.1934835   .0228414    -8.47   0.000    -.2382519   -.1487152
     GROWTH2 |   .0001606   .0000725     2.21   0.027     .0000185    .0003028
         AGE |  -.0001155   .0001729    -0.67   0.504    -.0004543    .0002234
          SE |  -.0035225   .0080167    -0.44   0.660     -.019235    .0121899
        MedE |     .01049   .0119458     0.88   0.380    -.0129234    .0339034
          LE |  -.0213549   .0185598    -1.15   0.250    -.0577314    .0150216
       _cons |   -.163565   .0278628    -5.87   0.000    -.2181752   -.1089548
------------------------------------------------------------------------------
```

Illustration 2

Model:

$$Log(Wage) = \beta_0 + \beta_1 Schooling + \beta_2 Exper + \beta_3 Exper^2 + \beta_4 SMSA + \beta_5 South + u$$

Aim:

- Estimating β_1 (returns to schooling)

Sample:

- 3010 North-American men aged between 24-34 years old

Details:

- Verbeek (2008), pp. 146-150

Illustration 2

Possible endogenous explanatory variable:

- $Schooling$: there are unobserved characteristics of working individuals (ability, motivation, intelligence) that simultaneously influence their wages and years of schooling

Possible instrumental variables:

- $NearCollege$ – may be relevant for attending a college or not (affects the costs of schooling); does not have a direct influence on wages
- $DadCollege, MomCollege$ – children's schooling choices are often highly correlated with the schooling characteristics of their parents; does not have a direct influence on wages

Illustration 2 – Question 1

```
. describe

  obs:         3,010
 vars:             9
 size:       108,360
-----------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
-----------------------------------------------------------------------------
NearCollege     float   %9.0g                 =1 if lived near a college in 1966
Schooling       float   %9.0g                 Years of schooling in 1976
DadCollege      float   %9.0g                 Father's years of schooling
MomCollege      float   %9.0g                 Mother's years of schooling
LWage           float   %9.0g                 Log(wage) in 1976
SMSA            float   %9.0g                 =1 if lives in a metropolitan area in 1976
South           float   %9.0g                 =1 if lives in the south in 1976
Exper           float   %9.0g                 Years of experience in 1976
Exper2          float   %9.0g                 Experience squared in 1976
-----------------------------------------------------------------------------
```

Illustration 2 – Question 2

```
. summarize

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
 NearCollege |      3010    .6820598    .4657535          0          1
   Schooling |      3010    13.26346    2.676913          1         18
  DadCollege |      3010    9.988904    3.266501          0         18
  MomCollege |      3010    10.33663     2.98751          0         18
       LWage |      3010    6.261832    .4437976    4.60517   7.784889
-------------+--------------------------------------------------------
        SMSA |      3010    .7129568    .4524571          0          1
       South |      3010    .4036545    .4907113          0          1
       Exper |      3010    8.856146    4.141672          0         23
      Exper2 |      3010    95.57907    84.61831          0        529
```

Illustration 2 – Question 3.1

```
. regress LWage Schooling Exper Exper2 SMSA South

      Source |       SS       df       MS              Number of obs =    3010
-------------+------------------------------           F(  5,  3004) =  214.57
       Model |  155.959798     5  31.1919596           Prob > F      =  0.0000
    Residual |  436.681848  3004  .145366794           R-squared     =  0.2632
-------------+------------------------------           Adj R-squared =  0.2619
       Total |  592.641646  3009  .196956346           Root MSE      =  .38127

------------------------------------------------------------------------------
       LWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |   .0815797    .003499    23.31   0.000     .0747189    .0884405
       Exper |   .0838357   .0067735    12.38   0.000     .0705545    .0971169
      Exper2 |  -.0022021   .0003238    -6.80   0.000    -.0028371   -.0015672
        SMSA |   .1508006    .015836     9.52   0.000     .1197501    .1818511
       South |  -.1751761   .0146486   -11.96   0.000    -.2038985   -.1464537
       _cons |   4.611015    .067895    67.91   0.000     4.477889     4.74414
------------------------------------------------------------------------------
```

Illustration 2 – Question 3.2

- Returns to schooling: 8,2%

- Experience:

$$\Delta Exper = 1 \Longrightarrow \Delta Wage = \beta_2 + 2\beta_3 Exper = 0.0838 - 0.0044 Exper$$

$$0.0838 - 0.0044 Exper = 0 \Rightarrow Exper = 19.0$$

  - Positive, decreasing effect until 19.0 years of experience
  - Negative, increasing (in absolute terms) effect after that point

```
. display _b[Exper]+2*_b[Exper2]*5
.06181454
. display _b[Exper]+2*_b[Exper2]*10
.03979339
(...)
```

$Exper$	$\Delta Wage$
0	8.4%
1	7.9%
5	6.2%
10	4.0%
20	-0.4%
30	-4.8%
45	-11.4%

Illustration 2 – Question 3.2 (cont.)

- $SMSA$:
  - The wages of workers living in metropolitan areas are on average 15.1% higher
  - Large firms, which usually offer better salaries, are more common in metropolitan areas

- $South$:
  - The wages of workers living in the South are on average 17.5% lower than wages of similar workers living in the North
  - The South of USA is a less attractive and poorer region

Illustration 2 – Question 3.3

- $Schooling, SMSA, South$:

$$H_0\colon \beta_j = 0, \qquad j = 1,4,5$$
$$H_1\colon \beta_j \neq 0$$
$$t = \frac{\hat{\beta}_j}{\hat{\sigma}_{\hat{\beta}_j}} \sim t_{N-p}$$

Variable	t	*p-value*
Schooling	23.31	0.000
SMSA	9.52	0.000
South	-11.96	0.000

  - Critical value (significance level: 5%):

```
.display invt(3010-6,0.975)
1.960754
```

$$t_{N-p} = 1.96$$

  - p-value (example for $SMSA$):

```
. display 2*ttail(3010-6,9.52)
3.435e-21
```

  - The null hypothesis is rejected in all cases, implying that the marginal effects of the three variables are relevant

Illustration 2 – Question 3.3 (cont.)

- $Exper$:

$$H_0\colon \beta_2 + 2\beta_3\overline{Exper} = 0$$
$$H_1\colon \beta_2 + 2\beta_3\overline{Exper} \neq 0$$

```
. summarize Exper
    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
       Exper |      3010    8.856146    4.141672          0         23
```

$$t = \frac{\hat{\beta}_2 + 2 * 8.856146 * \hat{\beta}_3}{\hat{\sigma}_{\hat{\beta}_2 + 2*8.856146*\hat{\beta}_3}} \sim t_{N-p}$$

- In Stata, it is easier to apply an *F* test (for a simple H_0, $F = t^2$):

```
. test Exper+2*Exper2*8.856146=0
( 1)  Exper + 17.71229*Exper2 = 0
      F(  1,  3004) =  375.17
           Prob > F =    0.0000
```

- The null hypothesis is rejected, implying that the marginal effect of $Exper$ is relevant

Illustration 2 – Question 4.1

Need to test:

- The exogeneity of $NearCollege$:

$$H_0: E(u|NearCollege) = 0$$
$$H_1: E(u|NearCollege) \neq 0$$

- The correlation between $NearCollege$ and $Schooling$:

$$H_0: cov(NearCollege, Schooling) = 0$$
$$H_1: cov(NearCollege, Schooling) \neq 0$$

Illustration 2 – Question 4.1 (cont.)

- Not possible to test whether $NearCollege$ is endogenous, since the number of instrumental variables and endogenous explanatory variables is identical $\longrightarrow$ use theoretical arguments

- Testing if $cov(NearCollege, Schooling) = 0$:
  - Estimate the reduced form model:

$$Schooling = \pi_0 + \pi_1 NearCollege + \pi_2 Exper + \pi_3 Exper^2 + \pi_4 SMSA + \pi_5 South + w$$

  - Test:

$$H_0: cov(NearCollege, Schooling) = 0 \Leftrightarrow H_0: \pi_1 = 0$$

    - The null hypothesis of no correlation between $NearCollege$ and $Schooling$ is rejected (see the next slide)

- Conclusion: $NearCollege$ is a valid instrument for $Schooling$

Illustration 2 – Question 4.1 (cont.)

```
. regress Schooling NearCollege Exper Exper2 SMSA South

      Source |       SS       df       MS              Number of obs =    3010
-------------+------------------------------           F(  5,  3004) =  496.39
       Model |  9755.15468     5  1951.03094           Prob > F      =  0.0000
    Residual |  11806.9254  3004  3.93040126           R-squared     =  0.4524
-------------+------------------------------           Adj R-squared =  0.4515
       Total |  21562.0801  3009  7.16586243           Root MSE      =  1.9825

------------------------------------------------------------------------------
   Schooling |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 NearCollege |   .3456458   .0841956     4.11   0.000      .180559    .5107326
       Exper |  -.4258437   .0343574   -12.39   0.000    -.4932102   -.3584773
      Exper2 |   .0009774   .0016838     0.58   0.562     -.002324    .0042789
        SMSA |   .3639914    .086559     4.21   0.000     .1942705    .5337122
       South |   -.582683   .0763963    -7.63   0.000    -.7324774   -.4328886
       _cons |   16.68131   .1800091    92.67   0.000     16.32836    17.03426
------------------------------------------------------------------------------
```

Illustration 2 – Question 4.2

Alternative 1: conclude the manual implementation of 2SLS:

- Complete the first step by obtaining an estimate for $Schooling$ based on the reduced form model:

```
. predict schoolhat
(option xb assumed; fitted values)
```

- Run the second step by estimating by OLS the structural model (with $Schooling$ replaced by $schoolhat$)
- Disadvantage: standard deviations are incorrectly estimated because the variability of $schoolhat$ is not taken into account

Alternative 2 (recommendable):

- Use the command `ivregress 2sls`, which automatically performs the two steps and computes correct variances

Illustration 2 – Question 4.2 (cont.)

Alternative 1

```
. regress LWage schoolhat Exper Exper2 SMSA South

      Source |       SS       df       MS              Number of obs =    3010
-------------+------------------------------           F(  5,  3004) =   91.27
       Model |  78.1556887     5  15.6311377           Prob > F      =  0.0000
    Residual |  514.485957  3004  .171266963           R-squared     =  0.1319
-------------+------------------------------           Adj R-squared =  0.1304
       Total |  592.641646  3009  .196956346           Root MSE      =  .41384

------------------------------------------------------------------------------
       LWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   schoolhat |   .1354201   .0508483     2.66   0.008     .0357191    .2351211
       Exper |   .1067727   .0228187     4.68   0.000     .0620308    .1515146
      Exper2 |  -.0022553    .000355    -6.35   0.000    -.0029514   -.0015591
        SMSA |   .1249987   .0297649     4.20   0.000      .066637    .1833603
       South |  -.1409356   .0359542    -3.92   0.000    -.2114329   -.0704383
       _cons |   3.703426   .8579277     4.32   0.000     2.021241    5.385611
------------------------------------------------------------------------------
```

Alternative 2

```
. ivregress 2sls LWage (Schooling = NearCollege) Exper Exper2 SMSA South

Instrumental variables (2SLS) regression          Number of obs  =      3010
                                                  Wald chi2(5)   =    499.36
                                                  Prob > chi2    =    0.0000
                                                  R-squared      =    0.2051
                                                  Root MSE       =    .39562

------------------------------------------------------------------------------
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |   .1354201   .0486085     2.79   0.005     .0401491     .230691
       Exper |   .1067727   .0218136     4.89   0.000     .0640188    .1495266
      Exper2 |  -.0022553   .0003394    -6.64   0.000    -.0029205    -.00159
        SMSA |   .1249987   .0284538     4.39   0.000     .0692302    .1807671
       South |  -.1409356   .0343705    -4.10   0.000    -.2083005   -.0735707
       _cons |   3.703426   .8201379     4.52   0.000     2.095986    5.310867
------------------------------------------------------------------------------
Instrumented:  Schooling
Instruments:   Exper Exper2 SMSA South NearCollege
```

Illustration 2 – Question 4.3

- OLS:
  - Returns to schooling: 8.2%
  - Standard error: 0.0035
  - 95% confidence interval: [7.5% ; 8.8%]

- 2SLS:
  - Returns to schooling: 13.5%
  - Standard error: 0.0486
  - 95% confidence interval: [4.0% ; 23.1%]

- OLS yields more precise results, which, however, will be inconsistent in case $Schooling$ is endogenous

Illustration 2 – Question 4.4

- Standard estimation of the variance:

```
. estat endogenous
    Tests of endogeneity
    Ho: variables are exogenous
    Durbin (score) chi2(1)          =  1.33097  (p = 0.2486)
    Wu-Hausman F(1,3003)            =  1.32846  (p = 0.2492)
```

- Robust estimation of the variance:

```
. quietly ivregress 2sls LWage (Schooling = NearCollege) Exper Exper2 SMSA
South, vce(robust)
. estat endogenous
     Tests of endogeneity
     Ho: variables are exogenous
     Robust score chi2(1)            =  1.39046  (p = 0.2383)
     Robust regression F(1,3003)     =  1.38821  (p = 0.2388)
```

- In both cases the null hypothesis of $Schooling$ being exogenous is not rejected
- OLS results are consistent

Illustration 2 – Question 5 (4.2)

```
. ivregress gmm LWage (Schooling = NearCollege) Exper Exper2 SMSA South,
wmatrix(unadjusted)

Instrumental variables (GMM) regression          Number of obs   =      3,010
                                                 Wald chi2(5)    =     499.36
                                                 Prob > chi2     =     0.0000
                                                 R-squared       =     0.2051
GMM weight matrix: Unadjusted                    Root MSE        =     .39562

------------------------------------------------------------------------------
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |   .1354201   .0486085     2.79   0.005     .0401491     .230691
       Exper |   .1067727   .0218136     4.89   0.000     .0640188    .1495266
      Exper2 |  -.0022553   .0003394    -6.64   0.000    -.0029205    -.00159
        SMSA |   .1249987   .0284538     4.39   0.000     .0692302    .1807671
       South |  -.1409356   .0343705    -4.10   0.000    -.2083005   -.0735707
       _cons |   3.703426   .8201379     4.52   0.000     2.095986    5.310867
------------------------------------------------------------------------------
Instrumented:  Schooling
Instruments:   Exper Exper2 SMSA South NearCollege
```

Needed if you want to get the same variances as 2SLS. Not efficient.

Illustration 2 – Question 5 (4.4)

```
. estat endogenous

  Test of endogeneity (orthogonality conditions)
  Ho: variables are exogenous

  GMM C statistic chi2(1) =  1.33097  (p = 0.2486)


. quietly ivregress gmm LWage (Schooling = NearCollege) Exper Exper2 SMSA
South

. estat endogenous

  Test of endogeneity (orthogonality conditions)
  Ho: variables are exogenous

   GMM C statistic chi2(1) =  1.39046  (p = 0.2383)
```

Illustration 2 – Question 6.1

```
. ivregress gmm LWage (Schooling = NearCollege DadCollege MomCollege) Exper
Exper2 SMSA South

Instrumental variables (GMM) regression          Number of obs   =      3,010
                                                 Wald chi2(5)    =     690.01
                                                 Prob > chi2     =     0.0000
                                                 R-squared       =     0.2365
GMM weight matrix: Robust                        Root MSE        =     .38771

------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |    .118024    .0111939    10.54   0.000     .0960844    .1399637
       Exper |   .0994424    .0082148    12.11   0.000     .0833417     .115543
      Exper2 |  -.0022445     .000339    -6.62   0.000     -.002909   -.0015801
        SMSA |   .1351776    .0165073     8.19   0.000      .102824    .1675312
       South |  -.1518082     .016665    -9.11   0.000     -.184471   -.1191455
       _cons |   3.995256    .1903674    20.99   0.000     3.622143    4.368369
------------------------------------------------------------------------------
Instrumented:  Schooling
Instruments:   Exper Exper2 SMSA South NearCollege DadCollege MomCollege
```

Illustration 2 – Question 6.1 (cont.)

- OLS:
  - Returns to schooling: 8.2%
  - Standard error: 0.0035
  - 95% confidence interval: [7.5% ; 8.8%]

- 2SLS (1 instrument):
  - Returns to schooling: 13.5%
  - Standard error: 0.0486
  - 95% confidence interval: [4.0% ; 23.1%]

- GMM (3 instruments):
  - Returns to schooling: 11.8%
  - Standard error: 0.0112
  - 95% confidence interval: [9.6% ; 14.0%]

Illustration 2 – Question 6.2

```
. estat endogenous

  Test of endogeneity (orthogonality conditions)
  Ho: variables are exogenous

  GMM C statistic chi2(1) =  11.6718  (p = 0.0006)
```

- The null hypothesis of $Schooling$ being exogenous is now rejected

- OLS results are inconsistent

Illustration 2 – Question 6.3

Test for the endogeneity of the instrumental variables:

```
. estat overid

  Test of overidentifying restriction:

 Hansen's J chi2(2) = 2.42011 (p = 0.2982)
```

- The hypothesis of the instrumental variables being exogenous is not rejected

Illustration 2 – Question 6.3 (cont.)

Test for the correlation between instruments and $Schooling$ (Stata automatic command):

```
. estat firststage

  First-stage regression summary statistics
  --------------------------------------------------------------------------
               |            Adjusted      Partial       Robust
      Variable |   R-sq.       R-sq.        R-sq.     F(3,3002)   Prob > F
  -------------+------------------------------------------------------------
     Schooling |  0.5070      0.5058       0.1047       102.032    0.0000
  --------------------------------------------------------------------------
```

- The null hypothesis is rejected $\longrightarrow$ instruments and endogenous covariate are correlated

Overall, $NearCollege, DadCollege$ and $MomCollege$ are valid instruments

Stata – Panel data

Commands for panel data:

- Prefix **xt**

Initial command:

- **xtset** *identvar tempvar*

Examples:

- **xtdescribe** [*varlist*]
- **xtsum** [*varlist*]
- **xttab** *varname*

Illustration 3

Model:

$$
\begin{aligned}
&Log(Wage)\\
&= \beta_0 + \beta_1 Schooling + \beta_2 Exper + \beta_3 Exper^2 + \beta_4 Union\\
&+ \beta_5 South + \beta_6 Public + u
\end{aligned}
$$

Aim:

- Estimating β_4 (impact of colective bargaining on wages)

Sample:

- 545 full-time working males who completed their schooling by 1980 and were observed over the period 1980-1987

Details:

- Verbeek (2008), pp. 375-377

Illustration 3 – Question 1

```
. xtset NR Year
       panel variable:  NR (strongly balanced)
        time variable:  YEAR, 1980 to 1987
                delta:  1 unit

. xtdescribe

      NR:  13, 17, ..., 12548                              n =        545
    YEAR:  1980, 1981, ..., 1987                           T =          8
           Delta(YEAR) = 1 unit
           Span(YEAR)  = 8 periods
           (NR*YEAR uniquely identifies each observation)

Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         8       8       8         8         8       8       8

     Freq.  Percent    Cum. |  Pattern
 ---------------------------+----------
      545    100.00  100.00 |  11111111
 ---------------------------+----------
      545    100.00         |  XXXXXXXX
```

Illustration 3 – Question 1 (cont.)

```
. describe

Contains data from F:\2-Econometric Methods I\Practice\Data\Data4.dta
  obs:         4,360
 vars:             9                          4 Sep 2018 08:56
 size:       156,960
--------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
--------------------------------------------------------------------------------
NR              float   %9.0g                 Observations number
Year            float   %9.0g                 Year of observation
Exper           float   %9.0g                 Years of experience
Public          float   %9.0g                 =1 if working in public
                                                administration
South           float   %9.0g                 =1 if lives in south
Schooling       float   %9.0g                 Years of schooling
Union           float   %9.0g                 =1 if wage set by collective
                                                bargaining
Exper2          float   %9.0g                 Experience squared
Wage            float   %9.0g                 Hourly wage
--------------------------------------------------------------------------------
Sorted by: NR  Year
```

Illustration 3 – Question 2

```
. summarize

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
          NR |      4,360    5262.059     3496.15         13      12548
        Year |      4,360      1983.5    2.291551       1980       1987
       Exper |      4,360    6.514679    2.825873          0         18
      Public |      4,360    .0401376    .1963044          0          1
       South |      4,360    .3506881    .4772402          0          1
-------------+---------------------------------------------------------
   Schooling |      4,360    11.76697    1.746181          3         16
       Union |      4,360    .2440367    .4295639          0          1
      Exper2 |      4,360    50.42477    40.78199          0        324
        Wage |      4,360    5.919175    3.202225   .0279014   57.50431
```

Illustration 3 – Question 2 (cont.)

```
. xtsum Wage Schooling Exper

Variable         |      Mean   Std. Dev.       Min        Max |    Observations
-----------------+--------------------------------------------+----------------
Wage     overall |  5.919175   3.202225   .0279014   57.50431 |     N =    4360
         between |             2.455819   1.503564   28.35696 |     n =     545
         within  |             2.057397  -16.42349   35.06652 |     T =       8
                 |                                            |
School~g overall |  11.76697   1.746181          3         16 |     N =    4360
         between |             1.747585          3         16 |     n =     545
         within  |                    0   11.76697   11.76697 |     T =       8
                 |                                            |
Exper    overall |  6.514679   2.825873          0         18 |     N =    4360
         between |             1.654918        3.5       14.5 |     n =     545
         within  |             2.291551   3.014679   10.01468 |     T =       8
```

Note: for Min and Max, in the within case, Stata considers the values of $(Y_{it} - \bar{Y}_i + \bar{Y})$, not $(Y_{it} - \bar{Y}_i)$.

Illustration 3 – Question 2 (cont.)

```
. xtsum Union South Public

Variable         |      Mean   Std. Dev.       Min        Max |    Observations
-----------------+--------------------------------------------+----------------
Union    overall |  .2440367   .4295639          0          1 |     N =    4360
         between |             .3294467          0          1 |     n =     545
         within  |             .2759787  -.6309633   1.119037 |     T =       8
                 |                                            |
South    overall |  .3506881   .4772402          0          1 |     N =    4360
         between |             .4644838          0          1 |     n =     545
         within  |             .1111732  -.5243119   1.225688 |     T =       8
                 |                                            |
Public   overall |  .0401376   .1963044          0          1 |     N =    4360
         between |             .1388064          0          1 |     n =     545
         within  |             .1389214  -.8348624   .9151376 |     T =       8
```

Illustration 3 – Question 3

```
. xttab Union

                  Overall             Between            Within
    Union |    Freq.  Percent      Freq.  Percent        Percent
----------+-----------------------------------------------------
        0 |    3296     75.60       511     93.76          80.63
        1 |    1064     24.40       280     51.38          47.50
----------+-----------------------------------------------------
    Total |    4360    100.00       791    145.14          68.90
                                (n = 545)
```

- Overall, 24,4% of wages resulted from collective bargaining
- For 51,38% of workers (280 out of 545), in at least one year their wages resulted from collective bargaining
- For those 280 workers, 47,5% of the time their wages resulted from collective bargaining

Illustration 3 – Question 3 (cont.)

```
. xttab South

                  Overall              Between            Within
    South |    Freq.  Percent      Freq.  Percent        Percent
----------+-----------------------------------------------------
        0 |     2831    64.93       374    68.62          94.62
        1 |     1529    35.07       212    38.90          90.15
----------+-----------------------------------------------------
    Total |     4360   100.00       586   107.52          93.00
                               (n = 545)
```

- Overall, 35,1% of observations concern cases of individuals living in the South
- 38,9% of workers (212 out of 545) lived at least one year in the South
- For those 212 workers, 90,15% of the time they lived in the South

Illustration 3 – Question 3 (cont.)

```
. xttab Public

                  Overall             Between            Within
    Public |    Freq.  Percent      Freq.  Percent        Percent
----------+-----------------------------------------------------
         0 |     4185    95.99        543    99.63          96.34
         1 |      175     4.01         62    11.38          35.28
----------+-----------------------------------------------------
     Total |     4360   100.00        605   111.01          90.08
                                  (n = 545)
```

- Overall, 4,01 % of observations concern cases of individuals working in Public Administration
- 11,38% of workers (62 out of 545) worked at least one year in Public Administration
- For those 62 workers, 35,28% of the time they worked in Public Administration

Illustration 3 – Question 4.1 - Pooled

```
. gen LWage=log(Wage)

. regress LWage Schooling Exper Exper2 Union South Public, vce(cluster NR)

Linear regression                                      Number of obs =    4360
                                                       F(  6,   544) =   60.28
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1704
                                                       Root MSE      =  .48546

                                   (Std. Err. adjusted for 545 clusters in NR)
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |   .1016358   .0090348    11.25   0.000     .0838885    .1193832
       Exper |   .0995979   .0121631     8.19   0.000     .0757054    .1234904
      Exper2 |  -.0031896   .0008552    -3.73   0.000    -.0048694   -.0015098
       Union |   .1709018   .0282839     6.04   0.000     .1153428    .2264608
       South |  -.0622494   .0328083    -1.90   0.058    -.1266958     .002197
      Public |   .0145377    .046524     0.31   0.755    -.0768511    .1059264
       _cons |  -.0552731   .1156887    -0.48   0.633    -.2825244    .1719783
------------------------------------------------------------------------------
. estimates store POOLED
```

Illustration 3 – Question 4.1 - Between

```
. xtreg LWage Schooling Exper Exper2 Union South Public, be

Linear regression                               Number of obs =     4360
                                                F(  6,    544) =    60.28
                                                Prob > F       =   0.0000
                                                R-squared      =   0.1704
                                                Root MSE       =   .48546

                              (Std. Err. adjusted for 545 clusters in NR)
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |   .1016358   .0090348    11.25   0.000     .0838885    .1193832
       Exper |   .0995979   .0121631     8.19   0.000     .0757054    .1234904
      Exper2 |  -.0031896   .0008552    -3.73   0.000    -.0048694   -.0015098
       Union |   .1709018   .0282839     6.04   0.000     .1153428    .2264608
       South |  -.0622494   .0328083    -1.90   0.058    -.1266958     .002197
      Public |   .0145377    .046524     0.31   0.755    -.0768511    .1059264
       _cons |  -.0552731   .1156887    -0.48   0.633    -.2825244    .1719783
------------------------------------------------------------------------------

. estimates store BE
```

Illustration 3 – Question 4.1 – Random Effects

```
. xtreg LWage Schooling Exper Exper2 Union South Public, re vce(cluster NR)
(...)

                                (Std. Err. adjusted for 545 clusters in NR)
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |   .1027451   .0086503    11.88   0.000     .0857907    .1196994
       Exper |   .1187223   .0104192    11.39   0.000     .0983012    .1391435
      Exper2 |  -.0043045   .0006748    -6.38   0.000     -.005627   -.0029819
       Union |   .1044636   .0209805     4.98   0.000     .0633425    .1455847
       South |  -.0166749   .0319162    -0.52   0.601    -.0792294    .0458797
      Public |   .0333681   .0334151     1.00   0.318    -.0321243    .0988606
       _cons |  -.1372221   .1113179    -1.23   0.218    -.3554012     .080957
-------------+----------------------------------------------------------------
     sigma_u |  .33131898
     sigma_e |  .35132742
         rho |  .47071506   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. estimates store RE
```

Illustration 3 – Question 4.1 – Fixed Effects

```
. xtreg LWage Schooling Exper Exper2 Union South Public, fe vce(cluster NR)
(...)

                                 (Std. Err. adjusted for 545 clusters in NR)
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |          0  (omitted)
       Exper |   .1206647   .0105609    11.43   0.000     .0999194    .1414099
      Exper2 |   -.004429   .0006836    -6.48   0.000    -.0057717   -.0030863
       Union |   .0833501   .0229404     3.63   0.000     .0382875    .1284127
       South |   .1038881   .0657487     1.58   0.115    -.0252644    .2330406
      Public |   .0363333   .0373874     0.97   0.332    -.0371081    .1097748
       _cons |   1.028155   .0425644    24.16   0.000     .9445442    1.111765
-------------+----------------------------------------------------------------
     sigma_u |  .41161426
     sigma_e |  .35132742
         rho |  .57852861   (fraction of variance due to u_i)
------------------------------------------------------------------------------
estimates store FE
```

Ignore

Illustration 3 – Question 4.1 - LSDV

```
. areg LWage Schooling Exper Exper2 Union South Public, absorb(NR) vce(cluster NR)
note: Schooling omitted because of collinearity
(...)

                                   (Std. Err. adjusted for 545 clusters in NR)
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |          0  (omitted)
       Exper |   .1206647   .0112897    10.69   0.000     .0984878    .1428415
      Exper2 |  -.004429    .0007307    -6.06   0.000    -.0058644   -.0029936
       Union |   .0833501   .0245235     3.40   0.001     .0351778    .1315225
       South |   .1038881    .070286     1.48   0.140    -.0341772    .2419534
      Public |   .0363333   .0399676     0.91   0.364    -.0421763     .114843
       _cons |   1.028155   .0455017    22.60   0.000     .9387742    1.117535
-------------+----------------------------------------------------------------
          NR |   absorbed                                     (545 categories)

. estimates store LSDV
```

Illustration 3 – Question 4.1 – 1st Table

```
. estimates table POOLED BE RE FE LSDV, b se
```

Variable	POOLED	BE	RE	FE	LSDV
Schooling	.10163583	.09800416	.10274505	(omitted)	(omitted)
	.00903478	.01092795	.00865032		
Exper	.09959789	-.04653615	.11872235	.12066465	.12066465
	.01216314	.05089296	.01041916	.01056093	.01128974
Exper2	-.00318958	.00523794	-.00430446	-.00442898	-.00442898
	.00085515	.00325606	.00067477	.00068355	.00073072
Union	.17090181	.26016332	.10446355	.08335012	.08335012
	.02828387	.0473469	.02098054	.02294039	.0245235
South	-.06224939	-.07078294	-.01667486	.1038881	.1038881
	.03280828	.03277295	.03191616	.06574874	.07028605
Public	.01453769	-.03308648	.03336815	.03633333	.03633333
	.04652403	.11079747	.03341515	.03738745	.03996755
_cons	-.05527309	.49764241	-.13722212	1.0281548	1.0281548
	.11568873	.22187872	.1113179	.04256437	.04550173

legend: b/se

Illustration 3 – Question 4.1 – 2nd Table

```
. estimates table POOLED BE RE FE LSDV, b star(0.1 0.05 0.01)

------------------------------------------------------------------------------
    Variable |    POOLED            BE              RE              FE        
-------------+----------------------------------------------------------------
   Schooling |  .10163583***    .09800416***    .10274505***    (omitted)     
       Exper |  .09959789***   -.04653615       .11872235***    .12066465***  
      Exper2 | -.00318958***    .00523794      -.00430446***   -.00442898***  
       Union |  .17090181***    .26016332***    .10446355***    .08335012***  
       South | -.06224939*     -.07078294**    -.01667486        .1038881     
      Public |  .01453769      -.03308648       .03336815       .03633333     
       _cons | -.05527309       .49764241**    -.13722212       1.0281548***  
------------------------------------------------------------------------------

------------------------------
    Variable |     LSDV       
-------------+----------------
   Schooling |  (omitted)     
       Exper |  .12066465***  
      Exper2 | -.00442898***  
       Union |  .08335012***  
       South |   .1038881     
      Public |  .03633333     
       _cons |  1.0281548***  
------------------------------
legend: * p<.1; ** p<.05; *** p<.01
```

Illustration 3 – Question 4.2

```
. quietly xtreg LWage Schooling Exper Exper2 Union South Public, re

. estimates store REs

. quietly xtreg LWage Schooling Exper Exper2 Union South Public, fe

. estimates store FEs
```

Illustration 3 – Question 4.2

```
. hausman FEs REs

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      FEs          REs         Difference          S.E.
-------------+----------------------------------------------------------------
       Exper |    .1206647     .1187223        .0019423        .0013976
      Exper2 |    -.004429    -.0043045       -.0001245        .0001211
       Union |    .0833501     .1044636       -.0211134        .0073043
       South |    .1038881    -.0166749         .120563        .0395946
      Public |    .0363333     .0333681        .0029652        .0124616
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        35.47
                Prob>chi2 =       0.0000
```

- Fixed effects estimator is better

Illustration 3 – Question 4.3

```
. regress D.LWage D.Schooling D.Exper D.Exper2 D.Union D.South D.Public,
vce(cluster NR) nocons
(…)
                                    (Std. Err. adjusted for 545 clusters in NR)
------------------------------------------------------------------------------
             |               Robust
     D.LWage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |
         D1. |          0  (omitted)
       Exper |
         D1. |    .119242   .0143533     8.31   0.000     .0910474    .1474366
      Exper2 |
         D1. |  -.0040136   .0009438    -4.25   0.000    -.0058676   -.0021596
       Union |
         D1. |   .0436369    .022141     1.97   0.049     .0001446    .0871292
       South |
         D1. |   .0811916   .0782312     1.04   0.300    -.0724807    .2348638
      Public |
         D1. |   .0425582   .0356367     1.19   0.233    -.0274442    .1125606
------------------------------------------------------------------------------
```

Illustration 3 – Question 4.4

```
. xtreg LWage Schooling Exper Exper2 c.Union##i.Year South Public, re vce(cluster NR)
```

Search help por fvvarlist

```
(…)

                                  (Std. Err. adjusted for 545 clusters in NR)
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Schooling |   .0922807   .0109883     8.40   0.000     .0707441    .1138174
       Exper |   .1080505   .0164482     6.57   0.000     .0758126    .1402885
      Exper2 |  -.0048138   .0007849    -6.13   0.000    -.0063523   -.0032753
       Union |   .1734667   .0477046     3.64   0.000     .0799674     .266966
             |
        Year |
       1981  |   .0568965   .0328633     1.73   0.083    -.0075144    .1213074
       1982  |   .0524367   .0390681     1.34   0.180    -.0241353    .1290087
       1983  |    .054367   .0474343     1.15   0.252    -.0386024    .1473364
       1984  |   .0742157   .0597359     1.24   0.214    -.0428645     .191296
       1985  |   .0860962   .0679065     1.27   0.205    -.0469982    .2191905
       1986  |   .1385142   .0775591     1.79   0.074    -.0134989    .2905273
       1987  |   .1885931   .0872509     2.16   0.031     .0175845    .3596018
             |
```

(continues in the next slide)

Illustration 3 – Question 4.4 (cont.)

```
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Year#c.Union |
       1981  |  -.0455982   .0555045    -0.82   0.411     -.154385    .0631886
       1982  |  -.0560189   .0543852    -1.03   0.303     -.162612    .0505742
       1983  |  -.0893266   .0555898    -1.61   0.108    -.1982806    .0196275
       1984  |  -.0692261   .0542253    -1.28   0.202    -.1755057    .0370534
       1985  |  -.0486523   .0527484    -0.92   0.356    -.1520373    .0547328
       1986  |  -.1301995   .0575233    -2.26   0.024    -.2429431   -.0174558
       1987  |   -.137896    .054057    -2.55   0.011    -.2438458   -.0319463
             |
       South |  -.0169016   .0319517    -0.53   0.597    -.0795258    .0457227
      Public |   .0386987    .033165     1.17   0.243    -.0263034    .1037009
       _cons |   .0002138   .1576026     0.00   0.999    -.3086817    .3091093
-------------+----------------------------------------------------------------
     sigma_u |  .33219311
     sigma_e |  .35091184
         rho |  .47261814   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Illustration 3 – Question 4.4 (cont.)

Benefit from collective barganing:

- 1980: 17.3%
- 1987: 17.3% - 13.8% = 3.5%

In 1987 wages defined by collective bargaining are still higher, but the differential relative to other wages decreased significantly.

Illustration 3 – Question 5.1

```
. xtivreg LWage Schooling Exper Exper2 (Union=L(1/4).Union) South Public, fe
vce(cluster NR)
------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       Union |   .0805339   .1312502     0.61   0.539    -.1767117    .3377795
   Schooling |          0  (omitted)
       Exper |   .1182598   .0293922     4.02   0.000     .0606523    .1758674
      Exper2 |  -.0035235   .0015683    -2.25   0.025    -.0065973   -.0004498
       South |   .0616019   .0860277     0.72   0.474    -.1070092     .230213
      Public |   .0297124   .0381017     0.78   0.435    -.0449655    .1043903
       _cons |   .9939431   .1367056     7.27   0.000     .7260049    1.261881
-------------+----------------------------------------------------------------
     sigma_u |  .45429733
     sigma_e |  .30701212
         rho |  .68648331   (fraction of variance due to u_i)
------------------------------------------------------------------------------
Instrumented:   Union
Instruments:    Schooling Exper Exper2 South Public L.Union L2.Union L3.Union
                L4.Union
------------------------------------------------------------------------------
```

Illustration 3 – Question 5.2

```
. xtivreg LWage Schooling Exper Exper2 (Union=L(1/2).Union F(1/2).Union) South
Public, fe vce(cluster NR)

------------------------------------------------------------------------------
             |               Robust
       LWage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       Union |    .043245   .1111023     0.39   0.697    -.1745114    .2610015
   Schooling |          0  (omitted)
       Exper |   .1167687   .0241845     4.83   0.000      .069368    .1641694
      Exper2 |  -.0045448   .0016055    -2.83   0.005    -.0076915   -.0013981
       South |   .1132399   .1198697     0.94   0.345    -.1217004    .3481802
      Public |   .0903547   .0451475     2.00   0.045     .0018673    .1788421
       _cons |   1.051376   .1040199    10.11   0.000     .8475009    1.255252
-------------+----------------------------------------------------------------
     sigma_u |  .45226025
     sigma_e |  .30141701
         rho |  .69243462   (fraction of variance due to u_i)
------------------------------------------------------------------------------
Instrumented:   Union
Instruments:    Schooling Exper Exper2 South Public L.Union L2.Union F.Union
                F2.Union
------------------------------------------------------------------------------
```

Illustration 4 – Model

- Trade-Off theory – optimal / target proportion of debt:

$$MDR_{it}^* = x_{i,t-1}'\beta + \eta_{it}$$

- Target adjustment model:

$$MDR_{it} - MDR_{i,t-1} = (1-\gamma)\left(MDR_{it}^* - MDR_{i,t-1}\right)$$

  - $0 \leq \gamma \leq 1$
  - Adjustment speed: $1 - \gamma$
    - $\gamma = 0 \Longrightarrow$ Firms adjust immediately and completely
    - $\gamma = 1 \Longrightarrow$ No adjustment

- Econometric model:

$$MDR_{it} = MDR_{i,t-1} + (1-\gamma)\left(x_{i,t-1}'\beta + \eta_{it} - MDR_{i,t-1}\right)$$

$$\vdots$$

$$MDR_{it} = \gamma MDR_{i,t-1} + x_{i,t-1}'\theta + \alpha_i + u_{it}$$

Illustration 4 – Model (cont.)

Aim:

- Estimate γ
- Test whether $H_0: \gamma = 1$ (trade-off theory not valid)

Sample:

- 5449 firms observed over the period 1986-2001
- Unbalanced panel
- Source: Compustat Industrial Annual Tapes

Details:

- Verbeek (2008), pp. 383-388

```
. xtset gvkey yeara
       panel variable:  gvkey (unbalanced)
        time variable:  yeara, 1986 to 2001, but with gaps
                delta:  1 unit
```

Illustration 4 – Question 1

```
. xtdescribe
   gvkey:  1003, 1004, ..., 233397                              n =       5449
   yeara:  1986, 1987, ..., 2001                                T =         16
           Delta(yeara) = 1 unit
           Span(yeara)  = 16 periods
           (gvkey*yeara uniquely identifies each observation)
Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         1       1       1         3         8      14      16
     Freq.  Percent    Cum. |  Pattern
 ---------------------------+------------------
      384      7.05    7.05 |  ...............1
      176      3.23   10.28 |  1111111111111111
      167      3.06   13.34 |  1...............
      149      2.73   16.08 |  ..............1.
      136      2.50   18.57 |  11..............
      132      2.42   20.99 |  ............1...
      131      2.40   23.40 |  .............1..
      113      2.07   25.47 |  111.............
       98      1.80   27.27 |  ...........1....
     3963     72.73  100.00 | (other patterns)
 ---------------------------+------------------
     5449    100.00         |  XXXXXXXXXXXXXXXX
```

Illustration 4 – Question 1 (cont.)

```
. describe

------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
------------------------------------------------------------------------------
gvkey           long    %12.0g                spc permanent number
yeara           int     %8.0g                 fiscal year
mdr             float   %9.0g                 market debt ratio
bdr             float   %9.0g                 book debt ratio
ebit_ta         float   %9.0g                 earnings before interest payments and taxes,
                                                divided by total assets (lag)
mb              float   %9.0g                 ratio of market value to book value of assets
                                                (lag)
dep_ta          float   %9.0g                 depreciation expenses as a proportion of fixed
                                                assets (lag)
lnta            float   %9.0g                 log of total assets (lag)
fa_ta           float   %9.0g                 proportion of fixed assts (lag)
rd_dum          byte    %8.0g                 =1 if research and development expenditures
                                                (lag)
rd_ta           float   %9.0g                 research and development expenditures, divided
                                                by total assets (lag)
indmedian       float   %9.0g                 industry median debt ratio (lag)
rated           byte    %8.0g                 =1 if firm has a public debt rating (lag)
------------------------------------------------------------------------------
```

Illustration 4 – Question 2

```
. quietly regress mdr L.mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta
indmedian rated, vce(cluster gvkey)

. estimates store POOLED

. quietly xtreg mdr L.mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta
indmedian rated, vce(cluster gvkey)

. estimates store RE

. quietly xtreg mdr L.mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta
indmedian rated, fe vce(cluster gvkey)

. estimates store FE
```

Illustration 4 – Question 2 (cont.)

```
. estimates table POOLED RE FE, b star

------------------------------------------------------------
    Variable |    POOLED           RE               FE
-------------+----------------------------------------------
         mdr |
         L1. |   .8835036***     .78734111***     .53498254***
             |
     ebit_ta | -.03233775***   -.03455703***   -.05003294***
          mb |   .0016432*       .00069052        .00227756*
      dep_ta | -.26051795***   -.30137705***   -.12395444
        lnta | -.00067042        .00183328*       .03803015***
       fa_ta |  .02012146***     .02919991***     .05934357***
      rd_dum |  .00688957**       .0096552***     .00005977
       rd_ta | -.12020508***   -.14520778***   -.06567621*
   indmedian |  .03212249**      .06029162***     .16721793***
       rated |  .00713406*       .01103821**      .02058981***
       _cons |  .05818177***     .03798629**     -.60083475***
------------------------------------------------------------
                      legend: * p<0.05; ** p<0.01; *** p<0.001
```

Illustration 4 – Question 3.1

```
. xtivreg mdr (L.mdr=L2.mdr) ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta
indmedian rated, fd
(…)
------------------------------------------------------------------------------
       D.mdr |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mdr |
         LD. |    7.03303   5.494343     1.28   0.201    -3.735684    17.80174
     ebit_ta |
         D1. |   1.207597   .9705551     1.24   0.213    -.6946564     3.10985
          mb |
         D1. |    .244267   .1853757     1.32   0.188    -.1190627    .6075966
      dep_ta |
         D1. |  -1.858345   1.577202    -1.18   0.239    -4.949603    1.232914
        lnta |
         D1. |  -.5214084   .4557998    -1.14   0.253     -1.41476    .3719429
(…)
------------------------------------------------------------------------------
Instrumented:   L.mdr
Instruments:    ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta indmedian rated
                L2.mdr
------------------------------------------------------------------------------
```

Illustration 4 – Question 3.2

```
. xtabond mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta indmedian rated,
twostep vce(robust)

Arellano-Bond dynamic panel-data estimation  Number of obs       =     15039
Group variable: gvkey                        Number of groups    =      2996
Time variable: yeara
                                             Obs per group:  min =         1
                                                             avg =  5.019693
                                                             max =        14

Number of instruments =    115               Wald chi2(10)       =    212.72
                                             Prob > chi2         =    0.0000
Two-step results
```

(continues in the next slide)

Illustration 4 – Question 3.2 (cont.)

```
                                  (Std. Err. adjusted for clustering on gvkey)
------------------------------------------------------------------------------
             |              WC-Robust
         mdr |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mdr |
         L1. |   .3819695   .0731919     5.22   0.000      .238516     .525423
             |
     ebit_ta |    .035684   .0173522     2.06   0.040     .0016744    .0696936
          mb |   .0147128   .0027217     5.41   0.000     .0093784    .0200472
      dep_ta |   .0648811    .109432     0.59   0.553    -.1496016    .2793639
        lnta |    .030107   .0083243     3.62   0.000     .0137916    .0464224
       fa_ta |   .0150317   .0286987     0.52   0.600    -.0412168    .0712801
      rd_dum |  -.0178784   .0122991    -1.45   0.146    -.0419841    .0062273
       rd_ta |    .001471    .035963     0.04   0.967    -.0690151    .0719571
   indmedian |   .0919917   .0453824     2.03   0.043     .0030439    .1809395
       rated |  -.0066174   .0099448    -0.67   0.506    -.0261088    .0128741
       _cons |  -.4235622   .1467658    -2.89   0.004    -.7112179   -.1359065
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).mdr
        Standard: D.ebit_ta D.mb D.dep_ta D.lnta D.fa_ta D.rd_dum D.rd_ta D.indmedian
                  D.rated
Instruments for level equation
        Standard: _cons
```

Illustration 4 – Question 3.3

```
. xtabond mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta indmedian rated,
twostep maxldep(2) vce(robust)

Arellano-Bond dynamic panel-data estimation  Number of obs        =     15039
Group variable: gvkey                        Number of groups     =      2996
Time variable: yeara
                                             Obs per group:    min =         1
                                                               avg =  5.019693
                                                               max =        14

Number of instruments =     37               Wald chi2(10)        =    179.25
                                             Prob > chi2          =    0.0000
Two-step results
```

(continues in the next slide)

Illustration 4 – Question 3.3 (cont.)

```
                                (Std. Err. adjusted for clustering on gvkey)
------------------------------------------------------------------------------
             |              WC-Robust
         mdr |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mdr |
         L1. |   .4005973   .0886448     4.52   0.000     .2268567     .574338
             |
     ebit_ta |   .0445636   .0197946     2.25   0.024      .005767    .0833603
          mb |   .0165177    .003106     5.32   0.000     .0104301    .0226053
      dep_ta |   .0832717   .1094867     0.76   0.447    -.1313182    .2978616
        lnta |   .0252836   .0090865     2.78   0.005     .0074744    .0430928
       fa_ta |   .0065411   .0306739     0.21   0.831    -.0535787    .0666608
      rd_dum |  -.0135049   .0122092    -1.11   0.269    -.0374345    .0104248
       rd_ta |   .0015315   .0361632     0.04   0.966    -.0693471      .07241
   indmedian |   .0670826   .0493198     1.36   0.174    -.0295825    .1637477
       rated |  -.0098843   .0101263    -0.98   0.329    -.0297315     .009963
       _cons |  -.3367156   .1575827    -2.14   0.033    -.6455719   -.0278593
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/3).mdr
        Standard: D.ebit_ta D.mb D.dep_ta D.lnta D.fa_ta D.rd_dum D.rd_ta
                  D.indmedian D.rated
Instruments for level equation
        Standard: _cons
```

Illustration 4 – Question 3.4

```
. xtdpdsys mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta indmedian rated,
twostep vce(robust)

System dynamic panel-data estimation            Number of obs         =     19573
Group variable: gvkey                           Number of groups      =      3777
Time variable: yeara
                                                Obs per group:    min =         1
                                                                  avg =  5.182155
                                                                  max =        15

Number of instruments =    129                  Wald chi2(10)         =   2185.15
                                                Prob > chi2           =    0.0000
Two-step results
```

(continues in the next slide)

Illustration 4 – Question 3.4 (cont.)

mdr	Coef.	WC-Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
mdr						
L1.	1.030104	.0238744	43.15	0.000	.9833112	1.076897
ebit_ta	.1285762	.018583	6.92	0.000	.0921541	.1649983
mb	.0312589	.0027109	11.53	0.000	.0259457	.0365722
dep_ta	-.1036924	.1374032	-0.75	0.450	-.3729978	.165613
lnta	-.0127849	.0068955	-1.85	0.064	-.0262999	.0007301
fa_ta	-.1085659	.0327925	-3.31	0.001	-.172838	-.0442939
rd_dum	-.0061031	.0153821	-0.40	0.692	-.0362514	.0240452
rd_ta	.0759739	.0441006	1.72	0.085	-.0104617	.1624096
indmedian	-.2372958	.0400293	-5.93	0.000	-.3157518	-.1588397
rated	-.0302876	.0120363	-2.52	0.012	-.0538783	-.006697
_cons	.273204	.1269921	2.15	0.031	.0243041	.522104

```
Instruments for differenced equation
        GMM-type: L(2/.).mdr
        Standard: D.ebit_ta D.mb D.dep_ta D.lnta D.fa_ta D.rd_dum D.rd_ta D.indmedian
                  D.rated
Instruments for level equation
        GMM-type: LD.mdr
        Standard: _cons
```

Illustration 4 – Question 4.1

```
. quietly xtabond mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta
indmedian rated, twostep vce(robust)

. estat abond, artests(3)

(…)

Arellano-Bond test for zero autocorrelation in first-differenced
errors
  +-----------------------+
  |Order |  z      Prob > z|
  |------+-----------------|
  |   1  | -6.206  0.0000 |
  |   2  | -3.587  0.0003 |
  |   3  |-3.3325  0.0009 |
  +-----------------------+
   H0: no autocorrelation
```

There is autocorrelation of order higher than 1: the estimators are not consistent.

Illustration 4 – Question 4.2

```
. quietly xtabond mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta
indmedian rated, twostep

. estat sargan
Sargan test of overidentifying restrictions
        H0: overidentifying restrictions are valid

        chi2(104)     =  436.3939
        Prob > chi2   =    0.0000
```

The hypothesis of exogenous instruments is rejected: the estimators are not consistent.

Illustration 4 – Question 4.3

```
. quietly xtabond mdr ebit_ta mb dep_ta lnta fa_ta rd_dum rd_ta
indmedian rated, twostep vce(robust)

. test L.mdr=1

 ( 1)  L.mdr = 1

           chi2(  1) =   71.30
         Prob > chi2 =    0.0000
```

The hypothesis that $\gamma = 1$ is rejected, which implies that firms seem to adjust their debt ratios: there is no evidence against the trade-off theory.