TUT2: Production Function Estimation

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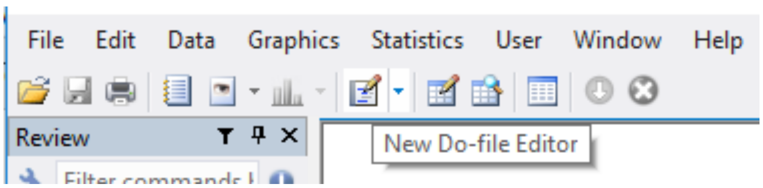
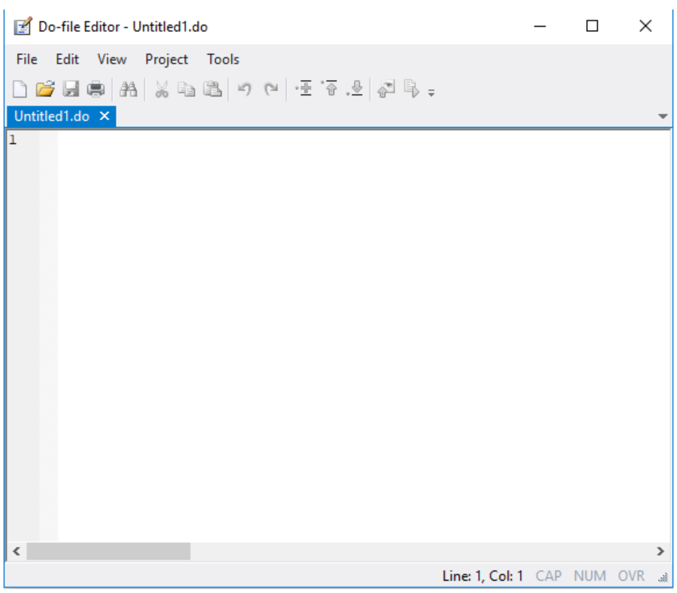
1. Create a do-file

The do-file contains the Stata commands that you wish to execute. Executing a do-file is the same as executing a series of commands interactively, only you have a permanent record of your commands. This allows you to quickly reproduce work you have already done and go from there.

Click the button shown as follows:



The do-file editor should open in a new window, with a clean page looking something like this:



2. Load the Blundell-Bond panel dataset

use "C:\Users\admin\Downloads\blundell_bond_2000_production_function.dta", clear

This directory depends on where you save the dataset. By typing “clear”, it specifies that it is okay to replace the data in memory, even though the current data have not been saved to disk

3. Pooled OLS

1) The simple version

reg ln_sales ln_capital ln_labor

```
. reg ln_sales ln_capital ln_labor

      Source |       SS           df       MS      Number of obs   =     4,072
-------------+----------------------------------   F(2, 4069)      =  63804.90
       Model |  15942.9273         2  7971.46365   Prob > F        =    0.0000
    Residual |  508.360451     4,069  .124934984   R-squared       =    0.9691
-------------+----------------------------------   Adj R-squared   =    0.9691
       Total |  16451.2878     4,071  4.04109255   Root MSE        =    .35346

------------------------------------------------------------------------------
    ln_sales |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_capital |   .4298586   .0079525    54.05   0.000     .4142675    .4454498
    ln_labor |    .560581   .0096412    58.14   0.000      .541679    .5794829
       _cons |   3.005052   .0293099   102.53   0.000     2.947588    3.062515
------------------------------------------------------------------------------
```

2) Adding time fixed effect into OLS regression

reg ln_sales ln_capital ln_labor i.year

```
. reg ln_sales ln_capital ln_labor i.year

      Source |       SS           df       MS      Number of obs   =     4,072
-------------+----------------------------------   F(9, 4062)      =  14254.66
       Model |  15946.3907         9  1771.82119   Prob > F        =    0.0000
    Residual |  504.897075     4,062  .124297655   R-squared       =    0.9693
-------------+----------------------------------   Adj R-squared   =    0.9692
       Total |  16451.2878     4,071  4.04109255   Root MSE        =    .35256

------------------------------------------------------------------------------
    ln_sales |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_capital |   .4322828   .0081396    53.11   0.000     .4163247    .4482409
    ln_labor |   .5578836   .0098286    56.76   0.000     .5386142     .577153
             |
        year |
       1983  |  -.0568626    .022107    -2.57   0.010    -.1002045   -.0135206
       1984  |   -.050041   .0221342    -2.26   0.024    -.0934362   -.0066458
       1985  |  -.0875714   .0221985    -3.94   0.000    -.1310926   -.0440503
       1986  |   -.092866   .0222691    -4.17   0.000    -.1365256   -.0492063
       1987  |  -.0580931   .0223043    -2.60   0.009    -.1018218   -.0143644
       1988  |  -.0211632   .0223277    -0.95   0.343    -.0649378    .0226114
       1989  |  -.0382923   .0224365    -1.71   0.088    -.0822802    .0056957
             |
       _cons |   3.046843   .0315266    96.64   0.000     2.985033    3.108652
------------------------------------------------------------------------------
```

We would like to control for time effects whenever unexpected variation or special events may affect the outcome variable. However, we do not have to create dummy variable manually by using “gen” command. By typing “i.year” when using regressions, we are controlling time fixed-effects by creating dummy variables for each year from a categorical variable: year.

Note: in the above table, year 1982 is omitted. By default, the first (smallest) value will be used as reference category.

3) Use clustered standard error

reg ln_sales ln_capital ln_labor i.year, vce(cluster id)

```
. reg ln_sales ln_capital ln_labor i.year, vce(cluster id)

Linear regression                               Number of obs     =      4,072
                                                F(9, 508)         =    2507.63
                                                Prob > F          =     0.0000
                                                R-squared         =     0.9693
                                                Root MSE          =     .35256

                                 (Std. Err. adjusted for 509 clusters in id)
```

ln_sales	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_capital	.4322828	.0274846	15.73	0.000	.3782853	.4862803
ln_labor	.5578836	.0308763	18.07	0.000	.4972227	.6185445
year						
1983	-.0568626	.0083657	-6.80	0.000	-.0732982	-.0404269
1984	-.050041	.0110933	-4.51	0.000	-.0718355	-.0282465
1985	-.0875714	.0135255	-6.47	0.000	-.1141442	-.0609987
1986	-.092866	.016461	-5.64	0.000	-.125206	-.0605259
1987	-.0580931	.0174944	-3.32	0.001	-.0924634	-.0237228
1988	-.0211632	.0185846	-1.14	0.255	-.0576754	.015349
1989	-.0382923	.020265	-1.89	0.059	-.0781058	.0015213
_cons	3.046843	.0915369	33.29	0.000	2.867005	3.22668

It is very unlikely that all observations in a data set are unrelated, but drawn from identical distributions. Some phenomena do not affect observations individually, but they affect groups of observations uniformly within each group. By using “vce(cluster id)” , we allow for correlation between observations. Clustered standard error will increase your confidence intervals. The higher the clustering level, the larger the resulting standard error. Hence, less stars in your tables.

4) Add lagged values as explanatory variables

reg ln_sales ln_capital ln_labor l.ln_sales l.ln_capital l.ln_labor i.year, vce(cluster id)

```
Linear regression                               Number of obs     =      3,563
                                                F(11, 508)        =   75113.93
                                                Prob > F          =     0.0000
                                                R-squared         =     0.9949
                                                Root MSE          =      .1426

                                   (Std. Err. adjusted for 509 clusters in id)
------------------------------------------------------------------------------
             |               Robust
    ln_sales |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_capital |   .2348098   .0352859     6.65   0.000     .1654854    .3041341
    ln_labor |   .4789653   .0288963    16.58   0.000     .4221944    .5357362
             |
    ln_sales |
         L1. |   .9216418   .0105283    87.54   0.000     .9009575    .9423261
             |
  ln_capital |
         L1. |  -.2120621   .0347141    -6.11   0.000     -.280263   -.1438613
             |
    ln_labor |
         L1. |  -.4233997   .0305806   -13.85   0.000    -.4834797   -.3633198
             |
        year |
        1984 |   .0661134   .0096619     6.84   0.000     .0471313    .0850956
        1985 |   .0127151   .0101712     1.25   0.212    -.0072678     .032698
        1986 |    .034839   .0102827     3.39   0.001     .0146373    .0550408
        1987 |   .0767564   .0086928     8.83   0.000     .0596782    .0938346
        1988 |   .0779253   .0094209     8.27   0.000     .0594167     .096434
        1989 |   .0356445   .0097659     3.65   0.000     .0164579    .0548311
             |
       _cons |    .246604   .0322971     7.64   0.000     .1831516    .3100564
------------------------------------------------------------------------------
```

By using "l.variables" , we are creating lagged values of those variables since expect the effects of labour/capital on outputs to appear with a delay. That is, this year's value of output may depend on last year's value of labour/capital/output rather than on the current value.

4. Within Groups (or fixed effects estimator)

A variety of commands are available for estimating fixed effects regressions. The most efficient method is the fixed effects regression (within-groups estimation).

Firstly, we want to declare data to be panel data; panel variable entered at first, time variable follows:

xtset id year

```
xtset id year
       panel variable:  id (strongly balanced)
        time variable:  year, 1982 to 1989
                delta:  1 unit
```

Notes: The terms balanced and unbalanced are often used to describe whether a
panel dataset is missing some observations. If a dataset does not contain a time variable, then panels are considered balanced if each panel contains the same number of observations; otherwise, the panels are unbalanced.
When the dataset contains a time variable, panels are said to be strongly balanced if each panel contains the same time points, weakly balanced if each panel contains the same number of observations but not the same time points, and unbalanced otherwise.

Stata's xtreg command is built for panel data regressions. Use the fe option to specify fixed effects:

xtreg ln_sales ln_labor ln_capital l.ln_sales l.ln_capital l.ln_labor i.year, fe vce(cluster id)

```
Fixed-effects (within) regression               Number of obs     =      3,563
Group variable: id                              Number of groups  =        509

R-sq:                                           Obs per group:
     within  = 0.7825                                         min =          7
     between = 0.9879                                         avg =        7.0
     overall = 0.9847                                         max =          7

                                                F(11,508)         =     345.86
corr(u_i, Xb)  = 0.7191                         Prob > F          =     0.0000

                                   (Std. Err. adjusted for 509 clusters in id)
------------------------------------------------------------------------------
             |               Robust
    ln_sales |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    ln_labor |   .4880013   .0299207    16.31   0.000     .4292178    .5467848
  ln_capital |   .1765454   .0340853     5.18   0.000     .1095799    .2435109
             |
    ln_sales |
         L1. |   .4039344   .0293221    13.78   0.000     .3463269    .4615418
             |
  ln_capital |
         L1. |  -.1305487   .0252882    -5.16   0.000    -.1802311   -.0808663
             |
    ln_labor |
         L1. |  -.0231194     .03455    -0.67   0.504    -.0909977     .044759
             |
        year |
        1984 |   .0564054   .0074048     7.62   0.000     .0418576    .0709533
        1985 |   .0271379   .0092935     2.92   0.004     .0088795    .0453963
        1986 |   .0494812   .0116301     4.25   0.000     .0266322    .0723302
        1987 |   .1033078   .0116548     8.86   0.000     .0804104    .1262053
        1988 |   .1310847     .01305    10.04   0.000     .1054461    .1567234
        1989 |   .1174383   .0150838     7.79   0.000      .087804    .1470726
             |
       _cons |   2.625541   .1591593    16.50   0.000      2.31285    2.938233
-------------+----------------------------------------------------------------
     sigma_u |  .31731619
     sigma_e |  .12076713
         rho |  .87347826   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

In the above table, the interpretations of all Coef. Standard error, T statistics, P value, Confidence interval are same as OLS regression's output. At the bottom, 'rho' represents how much of the variance is due to differences across panels. 'rho' is known as the intraclass correlation.

5. First differences GMM (or Arellano-Bond esitmator)

1) Search and install the command

Two Arellano–Bond estimators are available for Stata 9.0 – one incorporated into Stata 9+ (called xtabond) and one proprietor program written by Roodman (2006) (called xtabond2). xtabond2 can do everything that xtabond does and has many additional features. Since xtabond2 is not an official command of Stata 9+, it has to be downloaded. By searching the command:

search xtabond2

```
search for xtabond2

Search of official help files, FAQs, Examples, SJs, and STBs

SJ-12-4 st0159_1  . . . . . . . . . . . . . . . . Software update for xtabond2
        (help xtabond2 if installed)  . . . . . . . . . . . . . . . D. Roodman
        Q4/12   SJ 12(4):766--767
        bug fixes and added features such as support for factor
        variables

SJ-9-1  st0159  . . How to do xtabond2: An intro. to difference and system GMM
        (help xtabond2 if installed)  . . . . . . . . . . . . . . . D. Roodman
        Q1/09   SJ 9(1):86--136
        introduces linear GMM; describes how limited time span
        and potential for fixed effects and endogenous regressors
        drive the design of estimators; shows how to apply
        difference and system GMM estimators with xtabond2
```

Then by clicking the package and click "click here to install", you will complete the installment of the command:

```
package st0159_1 from http://www.stata-journal.com/software/sj12-4

TITLE
      SJ12-4 st0159_1. Update: 'XTABOND2': module to...

DESCRIPTION/AUTHOR(S)
      Update: 'XTABOND2': module to extend xtabond
        dynamic panel data estimator
      by David Roodman, Center for Global Development
      Support:  DRoodman@CGDEV.ORG
      After installation, type help xtabond2 and
        abar

INSTALLATION FILES                              (click here to install)
      st0159_1/xtabond2.ado
      st0159_1/xtabond2.mata
      st0159_1/xtabond2.hlp
      st0159_1/xtab2_p.ado
      st0159_1/lxtabond2.mlib
      st0159_1/abar.hlp
      st0159_1/abar.ado
```

Once you install "xtabond2", the following command shows the help file if you are not sure how to use it:
help xtabond2

2) Use Lag 2 + as instruments

The command xtabond2 is followed by the dependent variable (inv) and the list of all right-hand-side variables:

xtabond2 ln_sales ln_capital ln_labor l.ln_sales l.ln_capital l.ln_labor i.year, gmm(ln_sales ln_capital ln_labor, lag(2 .)) iv(i.year) robust noleveleq

After the comma are given two lists of variables. gmm( ) (or gmmstyle( )) lists the endogenous variables, which are instrumented with GMM-style instruments, i.e. lagged values of the variables in levels: Y,K,L. With lag (2 .) we have instructed Stata to use the second lag and following lags of the endogenous variables as instruments. The second lag is required, because it is not correlated with the current error term.

The second list of explanatory variables, iv ( ) (or ivstyle ( )), lists all strictly exogenous variables as well as the additional instrumental variables, therefore, are not listed before the comma in the Stata command. What this option essentially does for the included exogenous variables is tell Stata to use the variables themselves as their own instruments.

Robust specifies that the resulting standard errors are consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation. Nolevel (or noleveleq) tells Stata to apply the difference GMM estimator. By default, xtabond2 will apply the system GMM, if you don't specify nolevel. (System GMM is discussed in section 6)

```
Dynamic panel-data estimation, one-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =      3054
Time variable : year                            Number of groups   =       509
Number of instruments = 69                      Obs per group: min =         6
Wald chi2(13) =   1340.23                                      avg =      6.00
Prob > chi2   =     0.000                                      max =         6
------------------------------------------------------------------------------
             |               Robust
    ln_sales |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_capital |   .1318291   .1179029     1.12   0.264    -.0992562    .3629145
    ln_labor |   .5128697   .0892432     5.75   0.000     .3379563    .6877831
             |
    ln_sales |
         L1. |   .3264209   .0521606     6.26   0.000     .2241881    .4286538
             |
  ln_capital |
         L1. |  -.2066298   .0949589    -2.18   0.030    -.3927458   -.0205137
             |
    ln_labor |
         L1. |   .0726061   .0927269     0.78   0.434    -.1091353    .2543475
             |
        year |
        1982 |          0  (empty)
        1983 |  -.1899966   .0285349    -6.66   0.000     -.245924   -.1340691
        1984 |   -.122387   .0231032    -5.30   0.000    -.1676683   -.0771056
        1985 |  -.1334924    .017638    -7.57   0.000    -.1680623   -.0989225
        1986 |  -.0986976   .0134461    -7.34   0.000    -.1250514   -.0723437
        1987 |  -.0347582   .0108629    -3.20   0.001    -.0560491   -.0134673
        1988 |   .0028642   .0093652     0.31   0.760    -.0154913    .0212196
        1989 |          0  (omitted)
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year
    1989.year)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(2/7).(ln_sales ln_capital ln_labor)
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -6.21  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -1.36  Pr > z =  0.173
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(56)   = 213.56  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(56)   =  98.39  Prob > chi2 =  0.000
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year 1989.year)
    Hansen test excluding group:     chi2(50)   =  78.58  Prob > chi2 =  0.006
    Difference (null H = exogenous): chi2(6)    =  19.81  Prob > chi2 =  0.003
```

By default Stata reports three additional tests: Sargan test, AR(1) and AR(2) tests. The Sargan test has a null hypothesis of "the instruments as a group are exogenous". Therefore, the higher the p-value of the Sargan statistic the better. In robust estimation Stata reports the Hansen J statistic instead of the Sargan with the same null hypothesis.
The Arellano – Bond test for autocorrelation has a null hypothesis of no autocorrelation and is applied to the differenced residuals. The test for AR (2) in first differences is more important, because it will detect autocorrelation in levels.

3) Use Lag 3+ as instruments

The following command lag(3.) omits the levels of the variables dated t-2 from the set of instruments:

xtabond2 ln_sales ln_capital ln_labor l.ln_sales l.ln_capital l.ln_labor i.year, gmm(ln_sales ln_capital ln_labor, lag(3 .)) iv(i.year) robust noleveleq

```
Group variable: id                              Number of obs      =      3054
Time variable : year                            Number of groups   =       509
Number of instruments = 51                      Obs per group: min =         6
Wald chi2(13) =   1665.43                                      avg =      6.00
Prob > chi2   =     0.000                                      max =         6
------------------------------------------------------------------------------
             |              Robust
    ln_sales |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_capital |   .1940721    .153916     1.26   0.207    -.1075977    .4957419
    ln_labor |   .4987448    .101461     4.92   0.000     .2998848    .6976047
             |
    ln_sales |
         L1. |   .4261318   .0791759     5.38   0.000       .27095    .5813137
             |
  ln_capital |
         L1. |  -.1054642    .109791    -0.96   0.337    -.3206507    .1097223
             |
    ln_labor |
         L1. |  -.1469956    .113259    -1.30   0.194    -.3689792     .074988
             |
        year |
        1982 |          0  (empty)
        1983 |   -.092768   .0294955    -3.15   0.002     -.150578   -.0349579
        1984 |  -.0374932   .0211068    -1.78   0.076    -.0788618    .0038754
        1985 |  -.0676855   .0144321    -4.69   0.000    -.0959719   -.0393991
        1986 |  -.0491738   .0101795    -4.83   0.000    -.0691252   -.0292224
        1987 |          0  (omitted)
        1988 |   .0268377   .0081829     3.28   0.001     .0107994    .0428759
        1989 |   .0115639   .0149883     0.77   0.440    -.0178126    .0409405
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year
    1989.year)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(3/7).(ln_sales ln_capital ln_labor)
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -5.09  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.79  Pr > z =  0.429
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(38)   =  86.43  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(38)   =  53.66  Prob > chi2 =  0.047
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year 1989.year)
    Hansen test excluding group:     chi2(32)   =  45.74  Prob > chi2 =  0.055
    Difference (null H = exogenous): chi2(6)    =   7.92  Prob > chi2 =  0.244
```

6. System GMM (or Blundell-Bond esitmator)

Sometimes the lagged levels of the regressors are poor instruments for the first-differenced regressors. In this case, one should use the augmented version – “system GMM”. The system GMM estimator uses the levels equation to obtain a system of two equations: one differenced and one in levels. By adding the second equation additional instruments can be obtained. Therefore, the variables in levels in the second equation are instrumented with their own first differences. The command is following:

xtabond2 ln_sales ln_capital ln_labor l.ln_sales l.ln_capital l.ln_labor i.year, gmm(ln_sales ln_capital ln_labor, lag(2 .)) iv(i.year, equation(level)) robust h(1)

nolevel is not included after the comma in the command and Stata defaults to the system GMM. The h(1) option uses 2SLS as the one-step estimator, which is the value in the original implementation of the system GMM estimator in Blundell and Bond(1998).

The gmm(, lag(2 .)) option uses the lagged levels of Y, L and K dated t-2 and earlier as instruments for the equations in first-differences; and (correspondingly) the lagged first-differences of Y, L and K dated t-1 (only) as instruments for the equations in levels. This is the default specification of gmm-style instruments for the levels equations.

‘xtabond2’ offers the equation () sub-option, which specifies which equation should use the instruments: first-difference only (equation (diff)) or levels only (equation (level)). The default is both equations. In this case, the iv(i.year, equation(level)) option uses the year dummies as instruments for the equations in levels only.

Alternatively, using the following code, we choose lagged level from t-3 as instruments:

xtabond2 ln_sales ln_capital ln_labor l.ln_sales l.ln_capital l.ln_labor i.year, gmm(ln_sales ln_capital ln_labor, lag(3 .)) iv(i.year, equation(level)) robust h(1)

The gmm(, lag(3 .)) option uses the lagged levels of Y, L and K dated t-3 and earlier as instruments for the equations in first-differences; and (correspondingly) the lagged first-differences of Y, L and K dated t-2 (only) as instruments for the equations in levels.

The following tables are generated by the first type of code, i.e. lag(2):

```
Group variable: id                          Number of obs      =      3563
Time variable : year                        Number of groups   =       509
Number of instruments = 88                  Obs per group: min =         7
Wald chi2(13) = 404276.63                                  avg =      7.00
Prob > chi2   =    0.000                                   max =         7
```

ln_sales	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
ln_capital	.3666974	.130163	2.82	0.005	.1115826	.6218122
ln_labor	.623971	.1078013	5.79	0.000	.4126843	.8352578
ln_sales						
L1.	.4650298	.0520106	8.94	0.000	.3630909	.5669688
ln_capital						
L1.	-.3304688	.1063253	-3.11	0.002	-.5388625	-.1220752
ln_labor						
L1.	-.0925121	.109246	-0.85	0.397	-.3066303	.121606
year						
1982	0	(empty)				
1983	2.218975	.2356304	9.42	0.000	1.757147	2.680802
1984	2.266482	.2368093	9.57	0.000	1.802344	2.730619
1985	2.242476	.2399846	9.34	0.000	1.772115	2.712837
1986	2.271655	.2424574	9.37	0.000	1.796447	2.746863
1987	2.32348	.2427699	9.57	0.000	1.84766	2.799301
1988	2.348755	.2448667	9.59	0.000	1.868825	2.828685
1989	2.322886	.249252	9.32	0.000	1.834361	2.811411
_cons	0	(omitted)				

```
Instruments for first differences equation
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(2/7).(ln_sales ln_capital ln_labor)
Instruments for levels equation
  Standard
    1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year
    1989.year
    _cons
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    DL.(ln_sales ln_capital ln_labor)
```

```
Arellano-Bond test for AR(1) in first differences: z =  -8.17  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.60  Pr > z =  0.547

Sargan test of overid. restrictions: chi2(74)    = 118.62  Prob > chi2 =  0.001
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(74)    = 142.10  Prob > chi2 =  0.000
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(56)    =  97.03  Prob > chi2 =  0.001
    Difference (null H = exogenous): chi2(18)    =  45.07  Prob > chi2 =  0.000
  iv(1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year 1989.year, eq(level))
    Hansen test excluding group:     chi2(68)    = 122.25  Prob > chi2 =  0.000
    Difference (null H = exogenous): chi2(6)     =  19.85  Prob > chi2 =  0.003
```

The following tables are generated by the first type of code, i.e. lag(3):

```
Dynamic panel-data estimation, one-step system GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =      3563
Time variable : year                            Number of groups   =       509
Number of instruments = 67                      Obs per group: min =         7
Wald chi2(13) =  1.10e+06                                      avg =      7.00
Prob > chi2   =     0.000                                      max =         7
------------------------------------------------------------------------------
             |              Robust
    ln_sales |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  ln_capital |   .3998962   .1525718     2.62   0.009      .100861    .6989314
    ln_labor |   .4700393   .1128454     4.17   0.000     .2488664    .6912121
             |
    ln_sales |
         L1. |   .6119346   .0995041     6.15   0.000     .4169102     .806959
             |
  ln_capital |
         L1. |  -.2148848   .1198197    -1.79   0.073    -.4497272    .0199575
             |
    ln_labor |
         L1. |  -.2833138   .1211054    -2.34   0.019     -.520676   -.0459517
             |
        year |
        1982 |          0  (empty)
        1983 |   1.086769   .3515262     3.09   0.002     .3977903    1.775748
        1984 |   1.129477   .3472696     3.25   0.001     .4488413    1.810113
        1985 |   1.082243   .3521998     3.07   0.002     .3919436    1.772542
        1986 |   1.093936    .353472     3.09   0.002      .401144    1.786729
        1987 |   1.135014   .3535552     3.21   0.001     .4420586    1.827969
        1988 |   1.148466   .3594813     3.19   0.001     .4438952    1.853036
        1989 |   1.109807   .3611194     3.07   0.002     .4020261    1.817588
             |
       _cons |          0  (omitted)
------------------------------------------------------------------------------
Instruments for first differences equation
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(3/7).(ln_sales ln_capital ln_labor)
Instruments for levels equation
  Standard
    1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year
    1989.year
    _cons
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    DL2.(ln_sales ln_capital ln_labor)
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -6.71  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.42  Pr > z =  0.672
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(53)   = 58.86  Prob > chi2 =  0.270
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(53)   = 75.80  Prob > chi2 =  0.022
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(38)   = 46.28  Prob > chi2 =  0.168
    Difference (null H = exogenous): chi2(15)   = 29.53  Prob > chi2 =  0.014
  iv(1982b.year 1983.year 1984.year 1985.year 1986.year 1987.year 1988.year 1989.year, eq(level))
    Hansen test excluding group:     chi2(47)   = 64.28  Prob > chi2 =  0.048
    Difference (null H = exogenous): chi2(6)    = 11.52  Prob > chi2 =  0.074
```