# Quantitative Methods in Finance

## Tutorial, Part 16:
## *Dynamic panel data analysis.*

**Example 1:** Stata data file `traffic.dta` contains annual data on fatal transport injuries by USA states for the years 1982–1988. We focus on the following variables:

- *state*: U.S. state ID code;
- *year*: years 1982 to 1988;
- *fatal*: fatal transport injuries rate (per 10,000 inhabitants);
- *spircons*: spirits consumption;
- *perinc*: per capita personal income (in 1,000 USD).

Specify a dynamic panel data model for the fatal transport injuries rate (*fatal*) by employing as explanatory variables the first lag of the dependent variable, spirits consumption (*spircons*), per capita personal income (*perinc*) and a set of time dummies. The corresponding programming code is provided in the Stata Do file `traffic-commands.do`.

a) Load the data using the provided Stata data file. Explore the data using different panel structure Stata commands. Check the relationships among the variables graphically. What are the differences between static and dynamic panel data models?
b) Estimate the proposed model by employing the two-step Arellano–Bond or difference GMM estimator (use robust standard errors), assuming that the only endogeneity present is that involving the lagged dependent variable. What do you find?
c) Now, estimate the proposed model by employing the two-step system GMM estimator (use robust standard errors). This will utilize one more observation per state in the level equation. What do you find?
d) Examine the sensitivity of the results from point c) to collapsing the "GMM-style" instrument matrix.
e) Examine the sensitivity of the results from point c) to employing the forward orthogonal deviations transformation (instead of the first-differences transformation).
f) Based on the system GMM estimation results from point c), calculate the long-run effects of the relevant explanatory variables and interpret them.
g) Based on the system GMM estimation results from point c), calculate the (in-sample) predicted values of the fatal transport injuries rate and plot them against the actual values. What do you find?

***Computer printout of the results in Stata:***

*a) Data exploration:*

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

```
. xtdes

   state:  1, 4, ..., 56                                 n =         48
    year:  1982, 1983, ..., 1988                         T =          7
           Delta(year) = 1 unit
           Span(year)  = 7 periods
           (state*year uniquely identifies each observation)

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

     Freq.  Percent    Cum. |  Pattern
 ---------------------------+---------
       48    100.00  100.00 |  1111111
 ---------------------------+---------
       48    100.00         |  XXXXXXX
```

*b) Arellano-Bond (AB) or difference GMM estimation:*

```
. xi i.year
i.year            _Iyear_1982-1988    (naturally coded; _Iyear_1982 omitted)

. xtabond2 fatal l.fatal spircons perinc _I*, gmmstyle(l.fatal) ivstyle(spircons
  perinc _I*) noleveleq twostep robust
_Iyear_1984 dropped due to collinearity

Dynamic panel-data estimation, two-step difference GMM
------------------------------------------------------------------------------
Group variable: state                           Number of obs      =       240
Time variable : year                            Number of groups   =        48
Number of instruments = 22                      Obs per group: min =         5
Wald chi2(8)  =     57.69                                      avg =      5.00
Prob > chi2   =     0.000                                      max =         5
------------------------------------------------------------------------------
             |              Corrected
       fatal |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       fatal |
         L1. |   .1711995   .1498502     1.14   0.253    -.1225016    .4649006
             |
    spircons |   .4944253   .1309791     3.77   0.000     .2377109    .7511396
      perinc |   .0638268   .0438001     1.46   0.145    -.0220198    .1496734
 _Iyear_1983 |  -.0300156   .0298694    -1.00   0.315    -.0885586    .0285274
 _Iyear_1985 |  -.0349159    .024235    -1.44   0.150    -.0824156    .0125837
 _Iyear_1986 |   .0937901   .0333179     2.82   0.005     .0284881     .159092
 _Iyear_1987 |   .0715532   .0452124     1.58   0.114    -.0170614    .1601678
 _Iyear_1988 |   .0972075   .0579595     1.68   0.094    -.0163911    .2108061
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986
    _Iyear_1987 _Iyear_1988)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/6).L.fatal
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -2.45  Pr > z =  0.014
Arellano-Bond test for AR(2) in first differences: z =   0.77  Pr > z =  0.440
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(14)   =  16.03  Prob > chi2 =  0.311
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(14)   =   9.22  Prob > chi2 =  0.817
  (Robust, but weakened by many instruments.)
```

```
Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986 _Iyear_1987
  _Iyear_1988)
    Hansen test excluding group:     chi2(7)    =   5.12  Prob > chi2 =  0.646
    Difference (null H = exogenous): chi2(7)    =   4.10  Prob > chi2 =  0.768
```

*c) System GMM estimation:*

```
. xtabond2 fatal l.fatal spircons perinc _I*, gmmstyle(l.fatal) ivstyle(spircons
  perinc _I*) nocons twostep robust

Dynamic panel-data estimation, two-step system GMM
------------------------------------------------------------------------------
Group variable: state                           Number of obs      =       288
Time variable : year                            Number of groups   =        48
Number of instruments = 28                      Obs per group: min =         6
Wald chi2(9)  =  14992.73                                      avg =      6.00
Prob > chi2   =     0.000                                      max =         6
------------------------------------------------------------------------------
             |              Corrected
       fatal |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       fatal |
         L1. |   .6627355   .0733251     9.04   0.000     .5190209    .8064501
             |
    spircons |   .0614637   .0256571     2.40   0.017     .0111767    .1117508
      perinc |  -.0499487   .0129012    -3.87   0.000    -.0752346   -.0246628
 _Iyear_1983 |   1.123751   .2700004     4.16   0.000     .5945599    1.652942
 _Iyear_1984 |   1.250234   .2739692     4.56   0.000     .7132645    1.787204
 _Iyear_1985 |   1.206595   .2840366     4.25   0.000     .6498936    1.763297
 _Iyear_1986 |   1.324175   .2891966     4.58   0.000     .7573598     1.89099
 _Iyear_1987 |   1.301574   .2964686     4.39   0.000     .7205063    1.882642
 _Iyear_1988 |   1.349648   .3020469     4.47   0.000     .7576474    1.941649
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986
    _Iyear_1987 _Iyear_1988)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/6).L.fatal
Instruments for levels equation
  Standard
    spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986
    _Iyear_1987 _Iyear_1988
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    D.L.fatal
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.24  Pr > z =  0.001
Arellano-Bond test for AR(2) in first differences: z =   1.10  Pr > z =  0.270
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(19)   =  32.99  Prob > chi2 =  0.024
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(19)   =  20.43  Prob > chi2 =  0.369
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(14)   =  16.07  Prob > chi2 =  0.309
    Difference (null H = exogenous): chi2(5)    =   4.36  Prob > chi2 =  0.499
  iv(spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986 _Iyear_1987
  _Iyear_1988)
    Hansen test excluding group:     chi2(11)   =  12.70  Prob > chi2 =  0.313
    Difference (null H = exogenous): chi2(8)    =   7.73  Prob > chi2 =  0.461
```

*d) System GMM estimation with collapsing the instrument matrix:*

**. xtabond2 fatal l.fatal spircons perinc _I*, gmmstyle(l.fatal, collapse) ivstyle(spircons perinc _I*) nocons twostep robust**

```
Dynamic panel-data estimation, two-step system GMM
------------------------------------------------------------------------------
Group variable: state                           Number of obs      =       288
Time variable : year                            Number of groups   =        48
Number of instruments = 14                      Obs per group: min =         6
Wald chi2(9)  =  14072.61                                      avg =      6.00
Prob > chi2   =     0.000                                      max =         6
------------------------------------------------------------------------------
             |              Corrected
       fatal |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       fatal |
         L1. |   .6716104   .1183627     5.67   0.000     .4396237    .9035971
             |
    spircons |   .0812512    .035729     2.27   0.023     .0112236    .1512788
      perinc |  -.0521862   .0194585    -2.68   0.007    -.0903242   -.0140483
 _Iyear_1983 |   1.118921   .4236201     2.64   0.008      .288641    1.949201
 _Iyear_1984 |   1.218702   .4285761     2.84   0.004     .3787085    2.058696
 _Iyear_1985 |   1.170764   .4322054     2.71   0.007     .3236566    2.017871
 _Iyear_1986 |   1.324675   .4423621     2.99   0.003     .4576612    2.191689
 _Iyear_1987 |   1.291103   .4623848     2.79   0.005     .3848453     2.19736
 _Iyear_1988 |   1.323245   .4729206     2.80   0.005     .3963371    2.250152
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986
    _Iyear_1987 _Iyear_1988)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/6).L.fatal collapsed
Instruments for levels equation
  Standard
    spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986
    _Iyear_1987 _Iyear_1988
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    D.L.fatal collapsed
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.16  Pr > z =  0.002
Arellano-Bond test for AR(2) in first differences: z =   1.17  Pr > z =  0.241
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(5)    =  16.24  Prob > chi2 =  0.006
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(5)    =   7.04  Prob > chi2 =  0.218
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(4)    =   7.03  Prob > chi2 =  0.134
    Difference (null H = exogenous): chi2(1)    =   0.00  Prob > chi2 =  0.973
```

*e) System GMM estimation with FOD transformation:*

**. xtabond2 fatal l.fatal spircons perinc _I*, gmmstyle(l.fatal) ivstyle(spircons perinc _I*) nocons twostep robust orthogonal**

```
Dynamic panel-data estimation, two-step system GMM
------------------------------------------------------------------------------
Group variable: state                           Number of obs      =       288
Time variable : year                            Number of groups   =        48
Number of instruments = 28                      Obs per group: min =         6
```

```
Wald chi2(9)  =  14657.54                                      avg =      6.00
Prob > chi2   =     0.000                                      max =         6
------------------------------------------------------------------------------
             |              Corrected
       fatal |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       fatal |
         L1. |    .659888   .0730084     9.04   0.000     .5167941    .8029819
             |
    spircons |   .0627461   .0247965     2.53   0.011     .0141459    .1113464
      perinc |  -.0501173   .0127389    -3.93   0.000    -.0750851   -.0251495
 _Iyear_1983 |    1.12915   .2675122     4.22   0.000     .6048359    1.653464
 _Iyear_1984 |   1.255555    .271282     4.63   0.000     .7238522    1.787258
 _Iyear_1985 |   1.212173   .2812929     4.31   0.000     .6608491    1.763497
 _Iyear_1986 |   1.329903   .2865763     4.64   0.000     .7682234    1.891582
 _Iyear_1987 |   1.307494   .2937746     4.45   0.000      .731706    1.883281
 _Iyear_1988 |   1.355847    .299174     4.53   0.000     .7694764    1.942217
------------------------------------------------------------------------------
Instruments for orthogonal deviations equation
  Standard
    FOD.(spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986
    _Iyear_1987 _Iyear_1988)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/6).L.fatal
Instruments for levels equation
  Standard
    spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986
    _Iyear_1987 _Iyear_1988
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    D.L.fatal
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.24  Pr > z =  0.001
Arellano-Bond test for AR(2) in first differences: z =   1.10  Pr > z =  0.271
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(19)   =  39.01  Prob > chi2 =  0.004
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(19)   =  20.40  Prob > chi2 =  0.371
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(14)   =  16.09  Prob > chi2 =  0.308
    Difference (null H = exogenous): chi2(5)    =   4.31  Prob > chi2 =  0.506
  iv(spircons perinc _Iyear_1983 _Iyear_1984 _Iyear_1985 _Iyear_1986 _Iyear_1987
  _Iyear_1988)
    Hansen test excluding group:     chi2(11)   =  12.70  Prob > chi2 =  0.313
    Difference (null H = exogenous): chi2(8)    =   7.69  Prob > chi2 =  0.464
```

*f) Calculating the long-run effects:*

**. qui xtabond2 fatal l.fatal spircons perinc _I*, gmmstyle(l.fatal) ivstyle(spircons perinc _I*) nocons twostep robust**

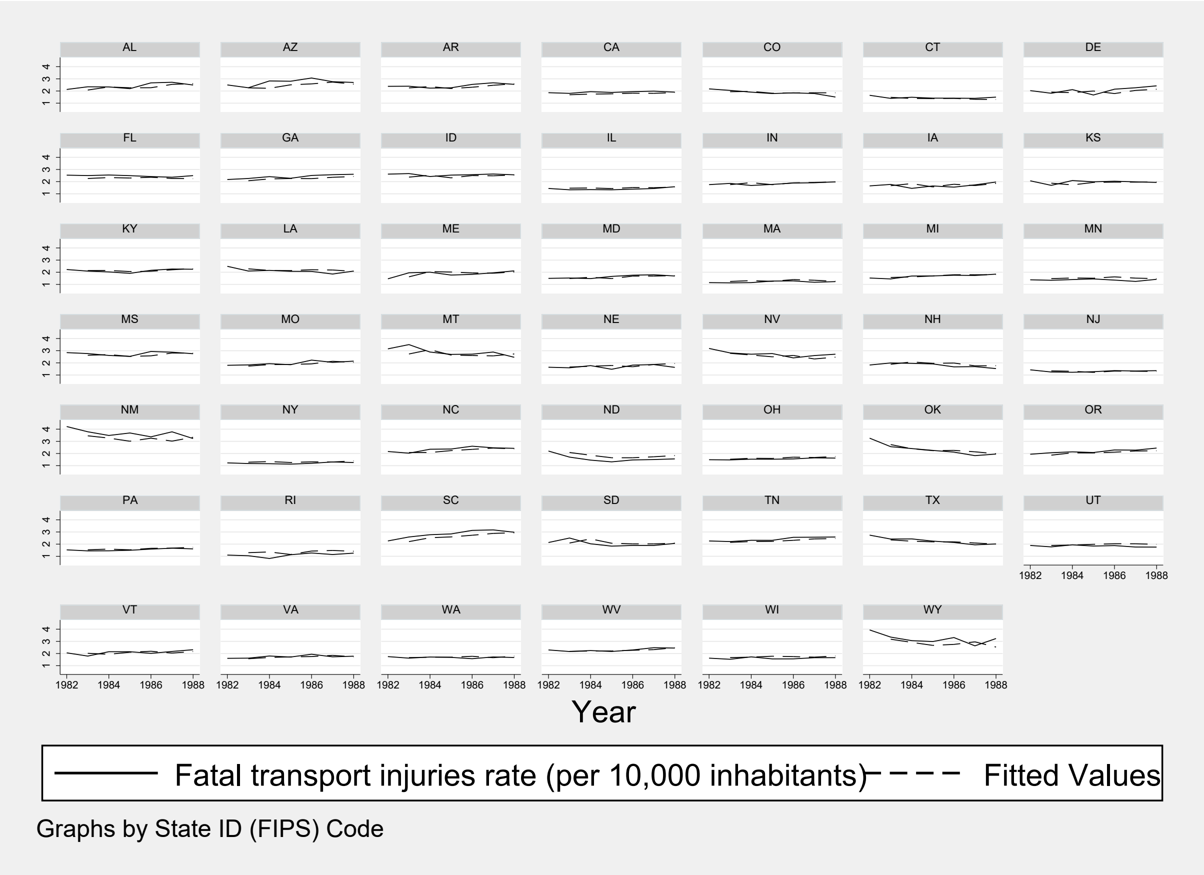
**. nlcom _b[spircons]/(1-_b[l.fatal])**

```
       _nl_1:  _b[spircons]/(1-_b[l.fatal])

------------------------------------------------------------------------------
       fatal |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |   .1822419   .0582665     3.13   0.002     .0680415    .2964422
------------------------------------------------------------------------------
```

```
. nlcom _b[perinc]/(1-_b[l.fatal])

       _nl_1:  _b[perinc]/(1-_b[l.fatal])

------------------------------------------------------------------------------
       fatal |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |  -.1480995   .0214495    -6.90   0.000    -.1901397   -.1060593
------------------------------------------------------------------------------
```

*g) In-sample prediction based on dynamic panel data estimation:*

```
. qui xtabond2 fatal l.fatal spircons perinc _I*, gmmstyle(l.fatal)
  ivstyle(spircons perinc _I*) nocons twostep robust

. predict fatal_hat
(option xb assumed; fitted values)
(48 missing values generated)

. xtline fatal fatal_hat, scheme(s2mono)
```




■

**Example 2:** Life expectancy at birth is an important indicator of a country's development level. The data on life expectancy at birth for the EU-28 countries are given in Stata data file `lifeexp.dta` for the years 2008–2013.

Specify a dynamic panel data model for life expectancy at birth (*le_0*) with the first lag of the dependent variable and percentage share of GDP spent on education (*educ_gdp*) as explanatory variables. The corresponding programming code is provided in the Stata Do file `lifeexp-commands.do`.

a) Load the data using the provided Stata data file. Explore the data using different panel structure Stata commands. Check the relationships among the variables graphically.
b) Estimate the proposed model first by the fixed-effects panel data estimator to address the potential impact of unobserved heterogeneity on the conditional mean (use panel-clustered standard errors). What do you find? Is the estimation approach appropriate?
c) Estimate the proposed model by employing the two-step Arellano–Bond or difference GMM estimator (use robust standard errors), assuming that the only endogeneity present is that involving the lagged dependent variable. What do you find?
d) Examine the sensitivity of the results in c) to estimating the equation with the forward orthogonal deviations transformation (instead of the first-differences transformation) and to the choice of "GMM-style" lag specification. What do you find?
e) Now, estimate the proposed model by employing the two-step system GMM estimator (use robust standard errors). This will utilize one more observation per country in the level equation. What do you find?
f) Based on the system GMM estimation results from point e), calculate the long-run effect of the only relevant explanatory variable. Is it statistically significant?
g) Based on the system GMM estimation results from point e), calculate the (in-sample) predicted values of the life expectancy at birth and plot them against the actual values. What do you find?

***Computer printout of the results in Stata:***

*a) Data exploration:*

```
. xtset country year
       panel variable:  country (strongly balanced)
        time variable:  year, 2008 to 2013
                delta:  1 unit

. xtdes

 country:  1, 2, ..., 28                                    n =         28
    year:  2008, 2009, ..., 2013                            T =          6
           Delta(year) = 1 unit
           Span(year)  = 6 periods
           (country*year uniquely identifies each observation)

Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         6       6       6         6         6       6       6

     Freq.  Percent    Cum. |  Pattern
 ---------------------------+---------
       28    100.00  100.00 |  111111
 ---------------------------+---------
       28    100.00         |  XXXXXX
```

```
. xtsum le_0 educ_gdp

Variable         |      Mean   Std. Dev.       Min        Max |    Observations
-----------------+--------------------------------------------+----------------
le_0     overall |  78.90179   2.957149       71.7       83.2 |     N =     168
         between |             2.953502       73.3      82.35 |     n =      28
         within  |             .5317186   77.21845   80.31845 |     T =       6
                 |                                            |
educ_gdp overall |  .7157143   .4652332         .1          2 |     N =     140
         between |             .4667415        .12        1.9 |     n =      28
         within  |             .0697374   .2957143   .9957143 |     T =       5
```

*b) Fixed-effects (FE) estimation:*

```
. xi i.year
i.year           _Iyear_2008-2013    (naturally coded; _Iyear_2008 omitted)

. xtreg le_0 l.le_0 educ_gdp _I*, fe vce(cluster country)
note: _Iyear_2013 omitted because of collinearity

Fixed-effects (within) regression               Number of obs     =        140
Group variable: country                         Number of groups  =         28

R-sq:                                           Obs per group:
     within  = 0.8274                                         min =          5
     between = 0.9409                                         avg =        5.0
     overall = 0.8920                                         max =          5

                                                F(6,27)           =     101.51
corr(u_i, Xb)  = 0.8700                         Prob > F          =     0.0000

                               (Std. Err. adjusted for 28 clusters in country)
------------------------------------------------------------------------------
             |               Robust
        le_0 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        le_0 |
         L1. |   .3396881    .120721     2.81   0.009     .0919891    .5873871
             |
    educ_gdp |   .5516655   .2306447     2.39   0.024     .0784216    1.024909
 _Iyear_2009 |  -.7280404    .141903    -5.13   0.000    -1.019201   -.4368796
 _Iyear_2010 |   -.520195   .0941619    -5.52   0.000    -.7133994   -.3269907
 _Iyear_2011 |  -.3113983   .0986873    -3.16   0.004    -.5138879   -.1089086
 _Iyear_2012 |  -.3726028   .0692139    -5.38   0.000     -.514618   -.2305876
 _Iyear_2013 |          0  (omitted)
       _cons |   52.28681   9.568726     5.46   0.000     32.65341    71.92021
-------------+----------------------------------------------------------------
     sigma_u |  1.9304726
     sigma_e |  .20119086
         rho |  .98925522   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

*c) Arellano-Bond (AB) or difference GMM estimation:*

```
. xtabond2 le_0 l.le_0 educ_gdp _I*, gmmstyle(l.le_0) ivstyle(educ_gdp _I*)
  noleveleq twostep robust
_Iyear_2009 dropped due to collinearity

Dynamic panel-data estimation, two-step difference GMM
------------------------------------------------------------------------------
Group variable: country                         Number of obs      =       112
Time variable : year                            Number of groups   =        28
Number of instruments = 15                      Obs per group: min =         4
```

```
Wald chi2(6)  =    906.29                                     avg =      4.00
Prob > chi2   =     0.000                                     max =         4
------------------------------------------------------------------------------
             |              Corrected
        le_0 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        le_0 |
         L1. |   .5921743   .1111794     5.33   0.000     .3742667    .8100818
             |
    educ_gdp |   .7445795   .1891675     3.94   0.000      .373818    1.115341
 _Iyear_2010 |   .1132801    .046742     2.42   0.015     .0216676    .2048927
 _Iyear_2011 |   .2876641   .0665333     4.32   0.000     .1572613    .4180669
 _Iyear_2012 |   .1294076   .1172816     1.10   0.270    -.1004601    .3592753
 _Iyear_2013 |   .4639807   .1050692     4.42   0.000     .2580488    .6699126
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/5).L.le_0
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -1.88  Pr > z =  0.060
Arellano-Bond test for AR(2) in first differences: z =  -1.71  Pr > z =  0.088
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(9)    =  28.58  Prob > chi2 =  0.001
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(9)    =   6.84  Prob > chi2 =  0.654
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
    Hansen test excluding group:     chi2(4)    =   3.18  Prob > chi2 =  0.529
    Difference (null H = exogenous): chi2(5)    =   3.67  Prob > chi2 =  0.598
```

*d) Sensitivity analysis / Robustness checks:*

```
. xtabond2 le_0 l.le_0 educ_gdp _I*, gmmstyle(l.le_0) ivstyle(educ_gdp _I*)
  noleveleq twostep robust orthogonal
_Iyear_2009 dropped due to collinearity

Dynamic panel-data estimation, two-step difference GMM
------------------------------------------------------------------------------
Group variable: country                         Number of obs      =       112
Time variable : year                            Number of groups   =        28
Number of instruments = 15                      Obs per group: min =         4
Wald chi2(6)  =   1021.28                                     avg =      4.00
Prob > chi2   =     0.000                                     max =         4
------------------------------------------------------------------------------
             |              Corrected
        le_0 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        le_0 |
         L1. |   .6023627   .1122181     5.37   0.000     .3824192    .8223062
             |
    educ_gdp |    .641227   .2308059     2.78   0.005     .1888558    1.093598
 _Iyear_2010 |   .1090137   .0463146     2.35   0.019     .0182387    .1997886
 _Iyear_2011 |   .2859414   .0654501     4.37   0.000     .1576616    .4142212
 _Iyear_2012 |   .1230907   .1178845     1.04   0.296    -.1079587    .3541402
 _Iyear_2013 |   .4534446   .1052688     4.31   0.000     .2471216    .6597677
------------------------------------------------------------------------------
Instruments for orthogonal deviations equation
  Standard
    FOD.(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
```

```
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/5).L.le_0
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -1.94  Pr > z =  0.053
Arellano-Bond test for AR(2) in first differences: z =  -1.65  Pr > z =  0.100
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(9)    = 27.54  Prob > chi2 =  0.001
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(9)    =  6.97  Prob > chi2 =  0.640
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
    Hansen test excluding group:     chi2(4)    =  3.17  Prob > chi2 =  0.530
    Difference (null H = exogenous): chi2(5)    =  3.80  Prob > chi2 =  0.578
```

**. xtabond2 le_0 l.le_0 educ_gdp _I*, gmmstyle(l.le_0, lag(2 4)) ivstyle(educ_gdp _I*) noleveleq twostep robust**

```
_Iyear_2009 dropped due to collinearity

Dynamic panel-data estimation, two-step difference GMM
------------------------------------------------------------------------------
Group variable: country                         Number of obs      =       112
Time variable : year                            Number of groups   =        28
Number of instruments = 11                      Obs per group: min =         4
Wald chi2(6)  =   1007.39                                      avg =      4.00
Prob > chi2   =     0.000                                      max =         4
------------------------------------------------------------------------------
             |              Corrected
        le_0 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        le_0 |
         L1. |   .8604665   .1929504     4.46   0.000     .4822906    1.238642
             |
    educ_gdp |   .8620968    .168033     5.13   0.000     .5327581    1.191435
 _Iyear_2010 |    .033504    .061839     0.54   0.588    -.0876983    .1547062
 _Iyear_2011 |   .1372019   .1037716     1.32   0.186    -.0661866    .3405905
 _Iyear_2012 |  -.1350646   .1857033    -0.73   0.467    -.4990364    .2289073
 _Iyear_2013 |   .1666024   .2016436     0.83   0.409    -.2286117    .5618165
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(2/4).L.le_0
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -1.74  Pr > z =  0.082
Arellano-Bond test for AR(2) in first differences: z =  -1.70  Pr > z =  0.089
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(5)    = 12.63  Prob > chi2 =  0.027
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(5)    =  3.53  Prob > chi2 =  0.619
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
    Hansen test excluding group:     chi2(0)    =  2.21  Prob > chi2 =      .
    Difference (null H = exogenous): chi2(5)    =  1.32  Prob > chi2 =  0.933
```

*e) System GMM estimation:*

**. xtabond2 le_0 l.le_0 educ_gdp _I*, gmmstyle(l.le_0) ivstyle(educ_gdp _I*) twostep robust**

```
_Iyear_2012 dropped due to collinearity
```

```
Dynamic panel-data estimation, two-step system GMM
------------------------------------------------------------------------------
Group variable: country                         Number of obs      =       140
Time variable : year                            Number of groups   =        28
Number of instruments = 20                      Obs per group: min =         5
Wald chi2(6)  =  12648.00                                      avg =      5.00
Prob > chi2   =     0.000                                      max =         5
------------------------------------------------------------------------------
             |              Corrected
        le_0 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        le_0 |
         L1. |   .9853722   .0111396    88.46   0.000     .9635391    1.007205
             |
    educ_gdp |   .1012346   .0440852     2.30   0.022     .0148292    .1876401
 _Iyear_2009 |   .2291256   .0457375     5.01   0.000     .1394819    .3187694
 _Iyear_2010 |   .2389252    .042554     5.61   0.000     .1555209    .3223296
 _Iyear_2011 |   .3334917   .0483901     6.89   0.000     .2386488    .4283346
 _Iyear_2013 |   .2959115   .0648673     4.56   0.000     .1687739    .4230492
       _cons |   1.133378   .9119755     1.24   0.214    -.6540613    2.920817
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/5).L.le_0
Instruments for levels equation
  Standard
    educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013
    _cons
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    D.L.le_0
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -2.09  Pr > z =  0.037
Arellano-Bond test for AR(2) in first differences: z =  -1.29  Pr > z =  0.196
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(13)   =  36.95  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(13)   =  11.72  Prob > chi2 =  0.551
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(9)    =   9.23  Prob > chi2 =  0.416
    Difference (null H = exogenous): chi2(4)    =   2.49  Prob > chi2 =  0.647
  iv(educ_gdp _Iyear_2009 _Iyear_2010 _Iyear_2011 _Iyear_2012 _Iyear_2013)
    Hansen test excluding group:     chi2(8)    =   6.41  Prob > chi2 =  0.602
    Difference (null H = exogenous): chi2(5)    =   5.31  Prob > chi2 =  0.379
```

*f) Calculating the long-run effect:*

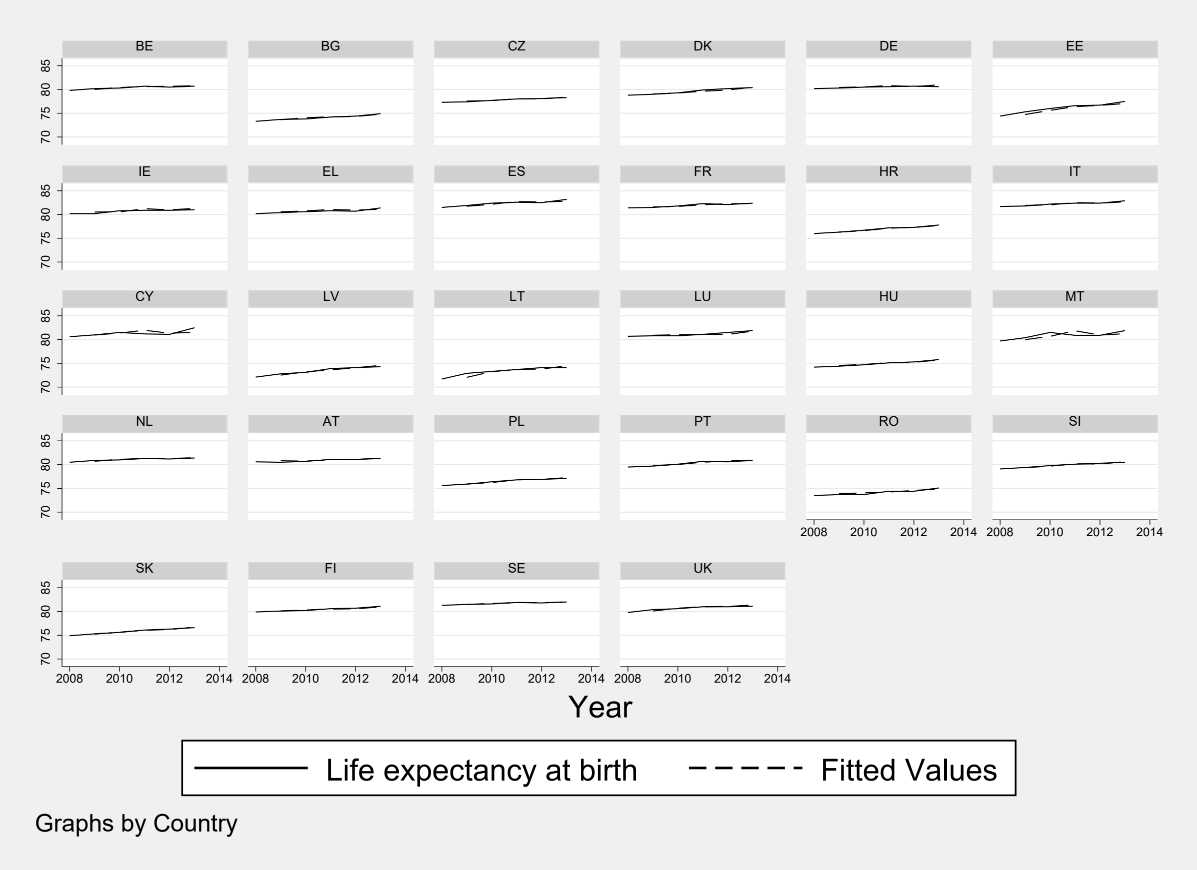
**. qui xtabond2 le_0 l.le_0 educ_gdp _I*, gmmstyle(l.le_0) ivstyle(educ_gdp _I*) twostep robust**

**. nlcom _b[educ_gdp]/(1-_b[l.le_0])**

```
       _nl_1:  _b[educ_gdp]/(1-_b[l.le_0])

------------------------------------------------------------------------------
        le_0 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |    6.92071   7.497338     0.92   0.356    -7.773803    21.61522
------------------------------------------------------------------------------
```

*g) In-sample prediction based on dynamic panel data estimation:*

```
. qui xtabond2 le_0 l.le_0 educ_gdp _I*, gmmstyle(l.le_0) ivstyle(educ_gdp _I*)
  twostep robust

. predict le_0_hat
(option xb assumed; fitted values)
(28 missing values generated)

. xtline le_0 le_0_hat, scheme(s2mono)
```




■