Example: We make use of the original Arellano and Bond (1991) dataset, available in Stata data file `ABdata.dta`. This is an unbalanced panel of annual labour demand data from 140 UK firms for the period 1976–1984. The programming code is given in Stata Do file `ABdata-commands.do`. The following variables are available:

- *id*: firm ID;
- *year*: year of observation;
- *emp*: employment;
- *wage*: wage;
- *cap*: capital;
- *indoutpt*: industrial output;
- *n*: log of employment;
- *w*: log of wage;
- *k*: log of capital;
- *ys*: log of industrial output;
- *nL1*: first lag of log employment;
- *nL2*: second lag of log employment;
- *wL1*: first lag of log wage;
- *kL1*: first lag of log capital;
- *kL2*: second lag of log capital;
- *ysL1*: first lag of log industrial output;
- *ysL2*: second lag of log industrial output;
- *yr1976–yr1984*: time dummy variables for given years.

In their original paper, Arellano and Bond (1991) modelled firms' employment *n* using a partial adjustment model to reflect the costs of hiring and firing, with two lags of employment. Other variables included were the current and lagged wage level *w*, the current, once- and twice-lagged capital stock *k* and the current, once- and twice-lagged output in the industrial sector *ys*. A set of time dummies is also included to capture business cycle effects.

a) Load the data using the provided Stata data file. Explore the data using different panel structure Stata commands. Check the relationships among variables graphically.
b) Estimate the proposed labour demand model ignoring its dynamic panel nature (use panel-clustered standard errors). What do you find? Why is this not a good idea?
c) Employ 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?
d) Apply the Anderson–Hsiao estimator to the first-differenced equation, instrumenting the lagged dependent variable with the twice-lagged level. What do you find? How could you approach estimating the labour demand function differently?
e) Employ the Arellano–Bond estimator and re-estimate the model (use robust standard errors, which are the same as panel-clustered standard errors here), assuming that the only endogeneity present is that involving the lagged dependent variable. What do you find?
f) Examine the sensitivity of the results in e) to the choice of "GMM-style" lag specification and to estimating the equation with the forward orthogonal deviations transformation (instead of the first-differences transformation). What do you find?

g) Consider that wages and the capital stock should not be taken as strictly exogenous in this context, unlike in the above models. This time, add the two-step estimation procedure with Windmeijer's finite-sample correction. What do you find?
h) Finally, following Blundell and Bond (1998), we specify a somewhat simpler model, dropping the second lags and removing sectoral demand. We consider wages and capital as potentially endogenous, with GMM-style instruments. Estimate this model with the one-step and two-step system GMM estimator (use robust standard errors).

Computer printout of the results in Stata:

Data exploration:

```
. xtset id year
       panel variable:  id (unbalanced)
        time variable:  year, 1976 to 1984
                delta:  1 unit

. xtdes

      id:  1, 2, ..., 140                                    n =        140
    year:  1976, 1977, ..., 1984                            T =          9
           Delta(year) = 1 unit
           Span(year)  = 9 periods
           (id*year uniquely identifies each observation)

Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         7       7       7         7         8       9       9

     Freq.  Percent    Cum. |  Pattern
 ---------------------------+-----------
       62     44.29   44.29 |  1111111..
       39     27.86   72.14 |  .1111111.
       19     13.57   85.71 |  .11111111
       14     10.00   95.71 |  111111111
        4      2.86   98.57 |  11111111.
        2      1.43  100.00 |  ..1111111
 ---------------------------+-----------
      140    100.00         |  XXXXXXXXX
```

"Pooled" OLS (POLS) estimation:

```
. regress n nL1 nL2 w wL1 k kL1 kL2 ys ysL1 ysL2 yr1979-yr1984, vce(cluster id)

Linear regression                               Number of obs     =        751
                                                F(16, 139)        =   13990.88
                                                Prob > F          =     0.0000
                                                R-squared         =     0.9944
                                                Root MSE          =     .10158

                                  (Std. Err. adjusted for 140 clusters in id)
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         nL1 |   1.044643   .0517969    20.17   0.000     .9422313    1.147055
         nL2 |  -.0765426   .0488082    -1.57   0.119    -.1730451    .0199598
           w |  -.5236727   .1740911    -3.01   0.003    -.8678817   -.1794637
         wL1 |   .4767538   .1717904     2.78   0.006     .1370937    .8164139
           k |   .3433951    .048649     7.06   0.000     .2472074    .4395829
         kL1 |  -.2018991   .0650327    -3.10   0.002    -.3304803    -.073318
```

```
         kL2 |  -.1156467   .0358966    -3.22   0.002    -.1866206   -.0446727
          ys |   .4328752     .17894     2.42   0.017      .079079    .7866715
        ysL1 |  -.7679125   .2514336    -3.05   0.003    -1.265041   -.2707836
        ysL2 |   .3124721   .1322678     2.36   0.020     .0509551    .5739891
      yr1979 |   .0158888   .0090408     1.76   0.081    -.0019865    .0337641
      yr1980 |   .0219933   .0149899     1.47   0.145    -.0076444    .0516309
      yr1981 |  -.0221532   .0242324    -0.91   0.362    -.0700648    .0257585
      yr1982 |  -.0150344   .0214242    -0.70   0.484    -.0573938    .0273251
      yr1983 |   .0073931     .01963     0.38   0.707    -.0314189    .0462052
      yr1984 |   .0153956   .0204269     0.75   0.452     -.024992    .0557832
       _cons |   .2747256   .3194854     0.86   0.391    -.3569538     .906405
------------------------------------------------------------------------------
```

Fixed-effects (FE) estimation:

. xtreg n nL1 nL2 w wL1 k kL1 kL2 ys ysL1 ysL2 yr1979-yr1984, fe vce(cluster id)

```
Fixed-effects (within) regression               Number of obs      =       751
Group variable: id                              Number of groups   =       140

R-sq:                                           Obs per group:
     within  = 0.7973                                         min =         5
     between = 0.9809                                         avg =       5.4
     overall = 0.9758                                         max =         7

                                                F(16,139)          =    152.18
corr(u_i, Xb)  = 0.5459                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 140 clusters in id)
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         nL1 |   .7329476   .0596831    12.28   0.000     .6149436    .8509516
         nL2 |  -.1394773   .0781564    -1.78   0.077    -.2940065    .0150519
           w |  -.5597445   .1596195    -3.51   0.001    -.8753406   -.2441484
         wL1 |   .3149987   .1430587     2.20   0.029     .0321463    .5978511
           k |   .3884188    .056928     6.82   0.000      .275862    .5009756
         kL1 |  -.0805185   .0538774    -1.49   0.137    -.1870436    .0260066
         kL2 |  -.0278013   .0426222    -0.65   0.515    -.1120728    .0564703
          ys |    .468666   .1712492     2.74   0.007     .1300759    .8072561
        ysL1 |  -.6285587   .2066106    -3.04   0.003    -1.037065   -.2200527
        ysL2 |   .0579764   .1326758     0.44   0.663    -.2043473    .3203001
      yr1979 |   .0046562   .0092572     0.50   0.616    -.0136469    .0229593
      yr1980 |   .0112327   .0158528     0.71   0.480    -.0201111    .0425765
      yr1981 |  -.0253693   .0249902    -1.02   0.312    -.0747794    .0240408
      yr1982 |  -.0343973    .022882    -1.50   0.135    -.0796391    .0108444
      yr1983 |  -.0280344   .0262074    -1.07   0.287     -.079851    .0237822
      yr1984 |  -.0119152   .0281652    -0.42   0.673    -.0676028    .0437723
       _cons |    1.79212    .633652     2.83   0.005     .5392775    3.044963
-------------+----------------------------------------------------------------
     sigma_u |  .22568151
     sigma_e |  .09395847
         rho |  .85227336   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Anderson-Hsiao (AH) estimation:

. ivregress 2sls D.n (D.nL1=nL2) D.(nL2 w wL1 k kL1 kL2 ys ysL1 ysL2 yr1980-yr1984)

```
Instrumental variables (2SLS) regression        Number of obs   =        611
                                                Wald chi2(15)   =      89.93
                                                Prob > chi2     =     0.0000
```

```
                                                R-squared       =          .
                                                Root MSE        =       .247
------------------------------------------------------------------------------
         D.n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         nL1 |
         D1. |   2.307626   1.973193     1.17   0.242    -1.559762    6.175013
             |
         nL2 |
         D1. |  -.2240271    .179043    -1.25   0.211    -.5749448    .1268907
             |
           w |
         D1. |  -.8103626    .261805    -3.10   0.002    -1.323491   -.2972342
             |
         wL1 |
         D1. |   1.422246   1.179492     1.21   0.228    -.8895156    3.734007
             |
           k |
         D1. |   .2530975   .1447404     1.75   0.080    -.0305884    .5367835
             |
         kL1 |
         D1. |  -.5524613   .6154929    -0.90   0.369    -1.758805    .6538825
             |
         kL2 |
         D1. |  -.2126364   .2397909    -0.89   0.375    -.6826179    .2573451
             |
          ys |
         D1. |   .9905803   .4630105     2.14   0.032     .0830965    1.898064
             |
        ysL1 |
         D1. |  -1.937912   1.438225    -1.35   0.178     -4.75678    .8809566
             |
        ysL2 |
         D1. |   .4870838   .5099415     0.96   0.339    -.5123832    1.486551
             |
      yr1980 |
         D1. |  -.0172951   .0442707    -0.39   0.696    -.1040641    .0694739
             |
      yr1981 |
         D1. |  -.1175214   .1133175    -1.04   0.300    -.3396197    .1045769
             |
      yr1982 |
         D1. |   -.174079     .15575    -1.12   0.264    -.4793433    .1311853
             |
      yr1983 |
         D1. |  -.2236667   .2060447    -1.09   0.278    -.6275068    .1801734
             |
      yr1984 |
         D1. |  -.2802887   .2691592    -1.04   0.298    -.8078309    .2472536
             |
       _cons |   .0626485   .0632517     0.99   0.322    -.0613226    .1866196
------------------------------------------------------------------------------
Instrumented:  D.nL1
Instruments:   D.nL2 D.w D.wL1 D.k D.kL1 D.kL2 D.ys D.ysL1 D.ysL2 D.yr1980
               D.yr1981 D.yr1982 D.yr1983 D.yr1984 nL2
```

Arellano-Bond (AB) or difference GMM estimation:

```
. xtabond n l(0/1).w l(0/2).(k ys) yr1979-yr1984, nocons lags(2) vce(robust)

Arellano-Bond dynamic panel-data estimation     Number of obs     =        611
Group variable: id                              Number of groups  =        140
Time variable: year
```

```
                                                Obs per group:
                                                              min =          4
                                                              avg =   4.364286
                                                              max =          6

Number of instruments =     41                  Wald chi2(16)      =    1727.45
                                                Prob > chi2        =     0.0000
One-step results
                                    (Std. Err. adjusted for clustering on id)
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .6862261   .1445943     4.75   0.000     .4028266    .9696257
         L2. |  -.0853582   .0560155    -1.52   0.128    -.1951467    .0244302
             |
           w |
         --. |  -.6078208   .1782055    -3.41   0.001    -.9570972   -.2585445
         L1. |   .3926237   .1679931     2.34   0.019     .0633632    .7218842
             |
           k |
         --. |   .3568456   .0590203     6.05   0.000      .241168    .4725233
         L1. |  -.0580012   .0731797    -0.79   0.428    -.2014308    .0854284
         L2. |  -.0199475   .0327126    -0.61   0.542    -.0840631    .0441681
             |
          ys |
         --. |   .6085073   .1725313     3.53   0.000     .2703522    .9466624
         L1. |  -.7111651   .2317163    -3.07   0.002    -1.165321   -.2570095
         L2. |   .1057969   .1412021     0.75   0.454    -.1709542     .382548
             |
      yr1979 |   .0095545   .0102896     0.93   0.353    -.0106127    .0297217
      yr1980 |   .0220152   .0177104     1.24   0.214    -.0126966     .056727
      yr1981 |  -.0117743   .0295079    -0.40   0.690    -.0696086      .04606
      yr1982 |  -.0270588   .0292751    -0.92   0.355    -.0844369    .0303193
      yr1983 |  -.0213204   .0304599    -0.70   0.484    -.0810207    .0383798
      yr1984 |  -.0077033   .0314106    -0.25   0.806     -.069267    .0538604
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).n
        Standard: D.w LD.w D.k LD.k L2D.k D.ys LD.ys L2D.ys D.yr1979
                  D.yr1980 D.yr1981 D.yr1982 D.yr1983 D.yr1984
```

. xtdpd l(0/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, dgmmiv(n) div(l(0/1).w l(0/2).(k ys) yr1979-yr1984) nocons vce(robust)

```
Dynamic panel-data estimation                   Number of obs      =        611
Group variable: id                              Number of groups   =        140
Time variable: year
                                                Obs per group:
                                                              min =          4
                                                              avg =   4.364286
                                                              max =          6

Number of instruments =     41                  Wald chi2(16)      =    1727.45
                                                Prob > chi2        =     0.0000
One-step results
                                    (Std. Err. adjusted for clustering on id)
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .6862261   .1445943     4.75   0.000     .4028266    .9696257
         L2. |  -.0853582   .0560155    -1.52   0.128    -.1951467    .0244302
```

```
             |
           w |
        --. |  -.6078208   .1782055    -3.41   0.001    -.9570972   -.2585445
        L1. |   .3926237   .1679931     2.34   0.019     .0633632    .7218842
             |
           k |
        --. |   .3568456   .0590203     6.05   0.000      .241168    .4725233
        L1. |  -.0580012   .0731797    -0.79   0.428    -.2014308    .0854284
        L2. |  -.0199475   .0327126    -0.61   0.542    -.0840631    .0441681
             |
          ys |
        --. |   .6085073   .1725313     3.53   0.000     .2703522    .9466624
        L1. |  -.7111651   .2317163    -3.07   0.002    -1.165321   -.2570095
        L2. |   .1057969   .1412021     0.75   0.454    -.1709542     .382548
             |
     yr1979 |   .0095545   .0102896     0.93   0.353    -.0106127    .0297217
     yr1980 |   .0220152   .0177104     1.24   0.214    -.0126966     .056727
     yr1981 |  -.0117743   .0295079    -0.40   0.690    -.0696086      .04606
     yr1982 |  -.0270588   .0292751    -0.92   0.355    -.0844369    .0303193
     yr1983 |  -.0213204   .0304599    -0.70   0.484    -.0810207    .0383798
     yr1984 |  -.0077033   .0314106    -0.25   0.806     -.069267    .0538604
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).n
        Standard: D.w LD.w D.k LD.k L2D.k D.ys LD.ys L2D.ys D.yr1979
                  D.yr1980 D.yr1981 D.yr1982 D.yr1983 D.yr1984
```

. xtabond2 n l(1/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, gmm(l.n) iv(l(0/1).w l(0/2).(k ys) yr1979-yr1984) noleveleq robust

```
Dynamic panel-data estimation, one-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       611
Time variable : year                            Number of groups   =       140
Number of instruments = 41                      Obs per group: min =         4
Wald chi2(16) =   1727.45                                      avg =      4.36
Prob > chi2   =     0.000                                      max =         6
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
        L1. |   .6862261   .1445943     4.75   0.000     .4028266    .9696257
        L2. |  -.0853582   .0560155    -1.52   0.128    -.1951467    .0244302
             |
           w |
        --. |  -.6078208   .1782055    -3.41   0.001    -.9570972   -.2585445
        L1. |   .3926237   .1679931     2.34   0.019     .0633632    .7218842
             |
           k |
        --. |   .3568456   .0590203     6.05   0.000      .241168    .4725233
        L1. |  -.0580012   .0731797    -0.79   0.428    -.2014308    .0854284
        L2. |  -.0199475   .0327126    -0.61   0.542    -.0840631    .0441681
             |
          ys |
        --. |   .6085073   .1725313     3.53   0.000     .2703522    .9466624
        L1. |  -.7111651   .2317163    -3.07   0.002    -1.165321   -.2570095
        L2. |   .1057969   .1412021     0.75   0.454    -.1709542     .382548
             |
     yr1979 |   .0095545   .0102896     0.93   0.353    -.0106127    .0297217
     yr1980 |   .0220152   .0177104     1.24   0.214    -.0126966     .056727
     yr1981 |  -.0117743   .0295079    -0.40   0.690    -.0696086      .04606
     yr1982 |  -.0270588   .0292751    -0.92   0.355    -.0844369    .0303193
     yr1983 |  -.0213204   .0304599    -0.70   0.484    -.0810207    .0383798
     yr1984 |  -.0077033   .0314106    -0.25   0.806     -.069267    .0538604
------------------------------------------------------------------------------
```

```
Instruments for first differences equation
  Standard
    D.(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983
    yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/8).L.n
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.60  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.52  Pr > z =  0.606
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(25)   =  67.59  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(25)   =  31.38  Prob > chi2 =  0.177
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(11)   =  12.01  Prob > chi2 =  0.363
    Difference (null H = exogenous): chi2(14)   =  19.37  Prob > chi2 =  0.151
```

. xtabond2 n l(1/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, gmm(l.n) iv(l(0/1).w l(0/2).(k ys) yr1979-yr1984) noleveleq robust small

```
Dynamic panel-data estimation, one-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       611
Time variable : year                            Number of groups   =       140
Number of instruments = 41                      Obs per group: min =         4
F(16, 140)    =    104.56                                      avg =      4.36
Prob > F      =     0.000                                      max =         6
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .6862261   .1469312     4.67   0.000     .3957352    .9767171
         L2. |  -.0853582   .0569209    -1.50   0.136    -.1978938    .0271774
             |
           w |
         --. |  -.6078208   .1810857    -3.36   0.001     -.965837   -.2498047
         L1. |   .3926237   .1707083     2.30   0.023     .0551242    .7301231
             |
           k |
         --. |   .3568456   .0599742     5.95   0.000     .2382734    .4754178
         L1. |  -.0580012   .0743625    -0.78   0.437    -.2050197    .0890174
         L2. |  -.0199475   .0332414    -0.60   0.549    -.0856674    .0457725
             |
          ys |
         --. |   .6085073   .1753198     3.47   0.001     .2618907    .9551239
         L1. |  -.7111651   .2354613    -3.02   0.003    -1.176685   -.2456454
         L2. |   .1057969   .1434843     0.74   0.462    -.1778792     .389473
             |
      yr1979 |   .0095545   .0104559     0.91   0.362    -.0111174    .0302263
      yr1980 |   .0220152   .0179967     1.22   0.223    -.0135652    .0575956
      yr1981 |  -.0117743   .0299848    -0.39   0.695    -.0710558    .0475072
      yr1982 |  -.0270588   .0297482    -0.91   0.365    -.0858727     .031755
      yr1983 |  -.0213204   .0309522    -0.69   0.492    -.0825145    .0398737
      yr1984 |  -.0077033   .0319183    -0.24   0.810    -.0708075    .0554009
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983
    yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/8).L.n
```

```
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.60  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.52  Pr > z =  0.606
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(25)   =  67.59  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(25)   =  31.38  Prob > chi2 =  0.177
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(11)   =  12.01  Prob > chi2 =  0.363
    Difference (null H = exogenous): chi2(14)   =  19.37  Prob > chi2 =  0.151
```

```
. xtabond2 n l(1/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, gmm(l.n, lag(2 5))
  iv(l(0/1).w l(0/2).(k ys) yr1979-yr1984) noleveleq robust small

Dynamic panel-data estimation, one-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       611
Time variable : year                            Number of groups   =       140
Number of instruments = 32                      Obs per group: min =         4
F(16, 140)    =     83.06                                    avg =      4.36
Prob > F      =     0.000                                    max =         6
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |    .835127   .3221088     2.59   0.011     .1983007    1.471953
         L2. |   .2621733   .1685585     1.56   0.122    -.0710759    .5954224
             |
           w |
         --. |  -.6708289    .210909    -3.18   0.002    -1.087807   -.2538504
         L1. |   .4361629   .2748179     1.59   0.115    -.1071669    .9794927
             |
           k |
         --. |   .3248221   .0656456     4.95   0.000     .1950372     .454607
         L1. |  -.1278657   .1236223    -1.03   0.303    -.3722736    .1165423
         L2. |  -.1697384   .0652074    -2.60   0.010     -.298657   -.0408198
             |
          ys |
         --. |   .6399356    .208263     3.07   0.003     .2281884    1.051683
         L1. |  -.7762311   .3621652    -2.14   0.034    -1.492251    -.060211
         L2. |   .0195998   .1917027     0.10   0.919    -.3594066    .3986063
             |
      yr1979 |   .0176478   .0152052     1.16   0.248    -.0124137    .0477092
      yr1980 |   .0367755    .025309     1.45   0.148    -.0132619    .0868128
      yr1981 |   .0067004   .0372447     0.18   0.857    -.0669343    .0803351
      yr1982 |  -.0033741   .0366047    -0.09   0.927    -.0757435    .0689953
      yr1983 |    .015233   .0321357     0.47   0.636     -.048301    .0787671
      yr1984 |   .0264333   .0272132     0.97   0.333    -.0273688    .0802353
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983
    yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(2/5).L.n
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -1.41  Pr > z =  0.158
Arellano-Bond test for AR(2) in first differences: z =  -2.08  Pr > z =  0.037
------------------------------------------------------------------------------
```

```
Sargan test of overid. restrictions: chi2(16)   =  24.69  Prob > chi2 =  0.075
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(16)   =  12.95  Prob > chi2 =  0.676
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(2)    =   1.40  Prob > chi2 =  0.497
    Difference (null H = exogenous): chi2(14)   =  11.56  Prob > chi2 =  0.642
```

```
. xtabond2 n l(1/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, gmm(l.n, lag(2 4))
  iv(l(0/1).w l(0/2).(k ys) yr1979-yr1984) noleveleq robust small

Dynamic panel-data estimation, one-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       611
Time variable : year                            Number of groups   =       140
Number of instruments = 29                      Obs per group: min =         4
F(16, 140)    =     70.46                                    avg =      4.36
Prob > F      =     0.000                                    max =         6
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   1.107051   .2808011     3.94   0.000      .551892     1.66221
         L2. |   .2314476   .1747884     1.32   0.188    -.1141184     .5770136
             |
           w |
         --. |  -.7087804   .2175692    -3.26   0.001    -1.138926    -.2786345
         L1. |   .6080322   .2624061     2.32   0.022     .0892411     1.126823
             |
           k |
         --. |   .3094885   .0680335     4.55   0.000     .1749827     .4439944
         L1. |  -.2112921   .1229065    -1.72   0.088    -.4542849     .0317007
         L2. |  -.2016251   .0656635    -3.07   0.003    -.3314453    -.0718049
             |
          ys |
         --. |   .6982485   .2026018     3.45   0.001     .2976938     1.098803
         L1. |   -.986704   .3457572    -2.85   0.005    -1.670285    -.3031235
         L2. |   .1115407    .198807     0.56   0.576    -.2815114     .5045929
             |
      yr1979 |   .0249425   .0149151     1.67   0.097    -.0045455     .0544305
      yr1980 |   .0497812   .0243869     2.04   0.043      .001567     .0979954
      yr1981 |   .0186416   .0371067     0.50   0.616    -.0547204     .0920035
      yr1982 |   .0136473   .0360617     0.38   0.706    -.0576487     .0849433
      yr1983 |   .0348068   .0348424     1.00   0.320    -.0340784     .1036921
      yr1984 |   .0397756   .0323804     1.23   0.221    -.0242421     .1037933
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983
    yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(2/4).L.n
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -2.04  Pr > z =  0.041
Arellano-Bond test for AR(2) in first differences: z =  -1.93  Pr > z =  0.054
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(13)   =  10.22  Prob > chi2 =  0.676
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(13)   =   9.75  Prob > chi2 =  0.714
  (Robust, but weakened by many instruments.)
```

```
. xtabond2 n l(1/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, gmm(l.n) iv(l(0/1).w
  l(0/2).(k ys) yr1979-yr1984) noleveleq robust small orthogonal

Dynamic panel-data estimation, one-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       611
Time variable : year                            Number of groups   =       140
Number of instruments = 41                      Obs per group: min =         4
F(16, 140)    =    141.12                                      avg =      4.36
Prob > F      =     0.000                                      max =         6
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .7366303   .1432181     5.14   0.000     .4534804     1.01978
         L2. |  -.0959867   .0696188    -1.38   0.170    -.2336267    .0416533
             |
           w |
         --. |  -.5630846   .1623771    -3.47   0.001    -.8841128   -.2420563
         L1. |    .316932   .1594257     1.99   0.049     .0017387    .6321253
             |
           k |
         --. |   .3842959   .0561362     6.85   0.000     .2733116    .4952802
         L1. |  -.0825036   .0699028    -1.18   0.240    -.2207052     .055698
         L2. |  -.0464861   .0438027    -1.06   0.290    -.1330863    .0401142
             |
          ys |
         --. |   .4687189   .1720873     2.72   0.007     .1284931    .8089448
         L1. |  -.6254982   .2187234    -2.86   0.005    -1.057926   -.1930702
         L2. |   .0419738   .1422144     0.30   0.768    -.2391916    .3231392
             |
      yr1979 |   .0054123   .0101154     0.54   0.593    -.0145863    .0254109
      yr1980 |   .0124428   .0164601     0.76   0.451    -.0200998    .0449854
      yr1981 |  -.0237689   .0263205    -0.90   0.368     -.075806    .0282682
      yr1982 |  -.0328046   .0241497    -1.36   0.177    -.0805499    .0149407
      yr1983 |  -.0251165   .0274078    -0.92   0.361    -.0793032    .0290703
      yr1984 |  -.0091826   .0272742    -0.34   0.737    -.0631052    .0447399
------------------------------------------------------------------------------
Instruments for orthogonal deviations equation
  Standard
    FOD.(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983
    yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/8).L.n
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -4.09  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.31  Pr > z =  0.758
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(25)   =  61.85  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(25)   =  31.61  Prob > chi2 =  0.170
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(w L.w k L.k L2.k ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(11)   =  11.09  Prob > chi2 =  0.436
    Difference (null H = exogenous): chi2(14)   =  20.52  Prob > chi2 =  0.115

. xtabond2 n l(1/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, gmm(l.(n w k))
  iv(l(0/2).ys yr1979-yr1984) noleveleq robust small

Dynamic panel-data estimation, one-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       611
Time variable : year                            Number of groups   =       140
```

```
Number of instruments = 90                      Obs per group: min =         4
F(16, 140)    =     85.29                                    avg =      4.36
Prob > F      =     0.000                                    max =         6
------------------------------------------------------------------------------
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .8179867   .0859779     9.51   0.000     .6480038    .9879695
         L2. |  -.1122756   .0502376    -2.23   0.027     -.211598   -.0129532
             |
           w |
         --. |  -.6816685   .1425842    -4.78   0.000    -.9635652   -.3997718
         L1. |   .6557083   .2023722     3.24   0.001     .2556076    1.055809
             |
           k |
         --. |   .3525689   .1218022     2.89   0.004     .1117594    .5933784
         L1. |  -.1536626   .0862946    -1.78   0.077    -.3242716    .0169464
         L2. |  -.0304529   .0321362    -0.95   0.345    -.0939879     .033082
             |
          ys |
         --. |   .6509498   .1895859     3.43   0.001     .2761283    1.025771
         L1. |  -.9162028   .2639328    -3.47   0.001    -1.438012   -.3943934
         L2. |   .2786584   .1855324     1.50   0.135    -.0881491     .645466
             |
      yr1979 |   .0113271   .0092007     1.23   0.220    -.0068632    .0295174
      yr1980 |   .0263688   .0173746     1.52   0.131    -.0079817    .0607193
      yr1981 |  -.0136266   .0289906    -0.47   0.639    -.0709426    .0436895
      yr1982 |   -.035061   .0300594    -1.17   0.245    -.0944901    .0243681
      yr1983 |  -.0308445   .0350441    -0.88   0.380    -.1001285    .0384396
      yr1984 |  -.0238987   .0367979    -0.65   0.517    -.0966502    .0488528
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/8).(L.n L.w L.k)
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -5.39  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.78  Pr > z =  0.436
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(74)   = 120.62  Prob > chi2 =  0.001
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(74)   =  73.72  Prob > chi2 =  0.487
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(65)   =  56.99  Prob > chi2 =  0.750
    Difference (null H = exogenous): chi2(9)    =  16.72  Prob > chi2 =  0.053
```

```
. xtabond2 n l(1/2).n l(0/1).w l(0/2).(k ys) yr1979-yr1984, gmm(l.(n w k))
 iv(l(0/2).ys yr1979-yr1984) noleveleq twostep robust small

Dynamic panel-data estimation, two-step difference GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       611
Time variable : year                            Number of groups   =       140
Number of instruments = 90                      Obs per group: min =         4
F(16, 140)    =     73.53                                    avg =      4.36
Prob > F      =     0.000                                    max =         6
------------------------------------------------------------------------------
```

```
             |              Corrected
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .8242881   .0968779     8.51   0.000     .6327553    1.015821
         L2. |  -.1013473   .0532617    -1.90   0.059    -.2066486     .003954
             |
           w |
         --. |  -.7113729   .1523716    -4.67   0.000     -1.01262   -.4101261
         L1. |   .6313503   .1783109     3.54   0.001     .2788201    .9838806
             |
           k |
         --. |   .3765693    .134755     2.79   0.006     .1101514    .6429872
         L1. |  -.1686157   .1128543    -1.49   0.137    -.3917346    .0545032
         L2. |  -.0581173   .0441827    -1.32   0.191    -.1454689    .0292344
             |
          ys |
         --. |   .6622805   .1703662     3.89   0.000     .3254575    .9991036
         L1. |  -.9428695   .2585638    -3.65   0.000    -1.454064   -.4316749
         L2. |   .3606436   .1961017     1.84   0.068      -.02706    .7483472
             |
      yr1979 |   .0168496   .0097548     1.73   0.086    -.0024361    .0361353
      yr1980 |   .0298765   .0163452     1.83   0.070    -.0024389    .0621919
      yr1981 |   -.011877   .0271608    -0.44   0.663    -.0655753    .0418213
      yr1982 |  -.0220118   .0311574    -0.71   0.481    -.0836116     .039588
      yr1983 |  -.0046468   .0389483    -0.12   0.905    -.0816498    .0723561
      yr1984 |  -.0015215   .0436207    -0.03   0.972    -.0877619    .0847189
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/8).(L.n L.w L.k)
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.92  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.77  Pr > z =  0.441
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(74)   = 120.62  Prob > chi2 =  0.001
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(74)   =  73.72  Prob > chi2 =  0.487
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  iv(ys L.ys L2.ys yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(65)   =  56.99  Prob > chi2 =  0.750
    Difference (null H = exogenous): chi2(9)    =  16.72  Prob > chi2 =  0.053
```

System GMM estimation:

. xtabond2 n l.n l(0/1).(w k) yr1977-yr1984, gmm(l.(n w k)) iv(yr1977-yr1984) nocons robust small

```
Dynamic panel-data estimation, one-step system GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       891
Time variable : year                            Number of groups   =       140
Number of instruments = 113                     Obs per group: min =         6
F(13, 140)    =   5234.29                                      avg =      6.36
Prob > F      =     0.000                                      max =         8
------------------------------------------------------------------------------
```

```
             |               Robust
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .9326197   .0267989    34.80   0.000     .8796369    .9856025
             |
           w |
         --. |  -.6305321    .120828    -5.22   0.000    -.8694155   -.3916486
         L1. |   .4597504   .1473406     3.12   0.002     .1684502    .7510507
             |
           k |
         --. |   .4820807   .0544203     8.86   0.000     .3744889    .5896725
         L1. |  -.4203043   .0593793    -7.08   0.000    -.5377004   -.3029083
             |
      yr1977 |   .6048596   .2341336     2.58   0.011     .1419648    1.067754
      yr1978 |   .6093746   .2239825     2.72   0.007     .1665492      1.0522
      yr1979 |   .6235068   .2210186     2.82   0.005     .1865412    1.060472
      yr1980 |   .6087174   .2226026     2.73   0.007     .1686202    1.048815
      yr1981 |   .5823737   .2222304     2.62   0.010     .1430122    1.021735
      yr1982 |   .6166492   .2244278     2.75   0.007     .1729434    1.060355
      yr1983 |   .6306819     .22592     2.79   0.006      .184026    1.077338
      yr1984 |   .6251536   .2261985     2.76   0.006     .1779469     1.07236
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(yr1977 yr1978 yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/8).(L.n L.w L.k)
Instruments for levels equation
  Standard
    yr1977 yr1978 yr1979 yr1980 yr1981 yr1982 yr1983 yr1984
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    D.(L.n L.w L.k)
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -5.37  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.27  Pr > z =  0.786
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(100)  = 157.09  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(100)  = 109.87  Prob > chi2 =  0.235
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(79)   =  83.60  Prob > chi2 =  0.340
    Difference (null H = exogenous): chi2(21)   =  26.27  Prob > chi2 =  0.196
  iv(yr1977 yr1978 yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(92)   = 105.44  Prob > chi2 =  0.160
    Difference (null H = exogenous): chi2(8)    =   4.43  Prob > chi2 =  0.817
```

`. xtabond2 n l.n l(0/1).(w k) yr1977-yr1984, gmm(l.(n w k)) iv(yr1977-yr1984) nocons twostep robust small`

```
Dynamic panel-data estimation, two-step system GMM
------------------------------------------------------------------------------
Group variable: id                              Number of obs      =       891
Time variable : year                            Number of groups   =       140
Number of instruments = 113                     Obs per group: min =         6
F(13, 140)    =   5340.55                                      avg =      6.36
Prob > F      =     0.000                                      max =         8
------------------------------------------------------------------------------
```

```
             |              Corrected
           n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
          L1. |   .9296378    .027678    33.59   0.000     .8749169    .9843587
             |
           w |
          --. |  -.6337777   .1206406    -5.25   0.000    -.8722906   -.3952647
          L1. |    .475294   .1417884     3.35   0.001     .1949706    .7556174
             |
           k |
          --. |   .4875227   .0604169     8.07   0.000     .3680753    .6069701
          L1. |  -.4238239   .0641954    -6.60   0.000    -.5507417   -.2969061
             |
       yr1977 |   .5699677   .2161691     2.64   0.009     .1425897    .9973457
       yr1978 |   .5752804   .2068362     2.78   0.006      .166354    .9842067
       yr1979 |   .5859308   .2049443     2.86   0.005      .180745    .9911166
       yr1980 |   .5755371   .2049077     2.81   0.006     .1704235    .9806506
       yr1981 |   .5476632   .2065027     2.65   0.009     .1393963    .9559302
       yr1982 |   .5825449   .2080911     2.80   0.006     .1711377    .9939521
       yr1983 |   .5965611   .2124743     2.81   0.006     .1764881    1.016634
       yr1984 |   .5911889   .2115818     2.79   0.006     .1728804    1.009497
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.(yr1977 yr1978 yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(1/8).(L.n L.w L.k)
Instruments for levels equation
  Standard
    yr1977 yr1978 yr1979 yr1980 yr1981 yr1982 yr1983 yr1984
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    D.(L.n L.w L.k)
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -5.54  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.25  Pr > z =  0.805
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(100)  = 157.09  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(100)  = 109.87  Prob > chi2 =  0.235
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(79)   =  83.60  Prob > chi2 =  0.340
    Difference (null H = exogenous): chi2(21)   =  26.27  Prob > chi2 =  0.196
  iv(yr1977 yr1978 yr1979 yr1980 yr1981 yr1982 yr1983 yr1984)
    Hansen test excluding group:     chi2(92)   = 105.44  Prob > chi2 =  0.160
    Difference (null H = exogenous): chi2(8)    =   4.43  Prob > chi2 =  0.817
```

■