xtseqreg: Sequential (two-stage) estimation of linear panel data models

and some pitfalls in the estimation of dynamic panel models

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`net install xtseqreg, from(http://www.kripfganz.de/stata/)` or `ssc install xtseqreg`

Time-invariant regressors in linear panel models

- In many applications, important determinants of the outcome variable can be time invariant.
  - Education, gender, nationality, ethnic and religious background, and other individual-specific characteristics play important roles in the determination of labor market or health outcomes.
  - Institutional, socio-economic, and geographic factors matter in convergence models of economic growth, and they are key variables in gravity models of international trade and investment flows.
- A researcher might be particularly interested in their effects. Yet, traditional "fixed-effects" procedures (`xtreg, fe`) wipe out all time-invariant variables from the model.

Time-invariant regressors in linear panel models

- To identify the coefficients of time-invariant regressors, the assumption that a sufficient number of regressors (or excluded instrumental variables) is uncorrelated with the unit-specific error component cannot be avoided.
- Identification strategies for static panel models include:
  - Classical "random-effects" model: `xtreg, re`,
  - "Correlated random-effects" (Mundlak, 1978; Chamberlain, 1982) or "hybrid" models (Allison, 2009; Schunck, 2013): `xthybrid` (Schunck and Perales, 2017),
  - Hausman and Taylor (1981) model: `xthtaylor`,
  - Other instrumental variables strategies: `xtivreg`.

Time-invariant regressors in linear panel models

- In the context of dynamic panel models, generalized method of moments (GMM) estimators (Arellano and Bover, 1995; Blundell and Bond, 1998) are frequently employed: `xtdpd`, `xtdpdsys`, and `xtabond2` (Roodman, 2009).
- Incorrect assumptions about the exogeneity of some variables may cause inconsistency of all coefficient estimates.
- A sequential procedure can provide partial robustness to such misspecification. In a first stage, only the coefficients of time-varying regressors are estimated. In a second stage, the coefficients of time-invariant regressors are recovered.

$\Rightarrow$ New Stata command: `xtseqreg`

Two-stage estimation

- Linear panel data model with time-invariant regressors and error-components structure:

$$y_{it} = \mathbf{x}_{it}'\beta + \mathbf{f}_i'\gamma + u_i + e_{it}$$

- Sequential estimation procedure:
  1. Estimation of the coefficients of time-varying regressors:

$$y_{it} = \mathbf{x}_{it}'\beta + \tilde{u}_i + e_{it}, \quad \tilde{u}_i = \mathbf{f}_i'\gamma + u_i$$

  2. Estimation of the coefficients of time-invariant regressors:

$$y_{it} - \mathbf{x}_{it}'\hat{\beta} = \mathbf{f}_i'\gamma + u_i + \tilde{e}_{it}, \quad \tilde{e}_{it} = e_{it} - \mathbf{x}_{it}'(\hat{\beta} - \beta)$$

- Conventional standard errors at the second stage are incorrect and often far too small.

$\Rightarrow$ `xtseqreg` computes proper standard errors with the analytical correction term derived by Kripfganz and Schwarz (2015).

Stata syntax of the xtseqreg command

Syntax

xtseqreg *depvar* [**(***indepvars1***)**] [*indepvars2*] [*if*] [*in*] [, *options*]

options	Description
Model	
first(*first_spec***)**	specify first-stage estimation results
both	estimate both stages
nocommonesample	do not restrict estimation samples to be the same
iv(*iv_spec***)**	standard instruments; can be specified more than once
gmmiv(*gmmiv_spec***)**	GMM-type instruments; can be specified more than once
wmatrix(*wmat_spec***)**	specify initial weighting matrix
twostep	compute two-step instead of one-step estimator
teffects	add time effects to the model
noconstant	suppress constant term
SE/Robust	
vce(*vcetype***)**	*vcetype* may be **conventional**, **ec**, or **robust**
Reporting	
combine	combine the estimation results for both equations
level(*#***)**	set confidence level; default is **level(95)**
noheader	suppress output header
notable	suppress coefficient table
noomitted	suppress omitted variables

Stata syntax of xtseqreg postestimation commands

Syntax for predict

```
predict [type] newvar [if] [in] [, xb stdp ue xbu u e equation(eqno)]

predict [type] {stub*|newvar1 ... newvarq} [if] [in] , scores
```

Syntax for estat

Arellano-Bond test for autocorrelated residuals

```
estat serial [, ar(numlist)]
```

Hansen's J-test of overidentifying restrictions

```
estat overid
```

Difference-in-Hansen test of overidentifying restrictions

```
estat overid name
```

Generalized Hausman test for model misspecification

```
estat hausman name [(varlist)] [, df(#) nonested]
```

where *name* is a name under which estimation results were stored via **estimates store**.

Empirical example: distance and FDI

- Estimation of a gravity model for U.S. outward FDI.
- Annual data, 1989–1999, for 341 bilateral industry-level relationships, compiled by Egger and Pfaffermayr (2004).

```
. describe

Contains data from C:\data_us.dta
  obs:         2,767                          Egger and Pfaffermayr (2004, JAE)
 vars:            13                          8 Aug 2003 03:39
 size:       118,981
------------------------------------------------------------------------------------------
              storage   display    value
variable name   type    format     label      variable label
------------------------------------------------------------------------------------------
ind             byte    %9.0g                 industry identifier
codeim          int     %8.0g                 country identifier
year            int     %9.0g                 year
lrfdi           float   %9.0g                 log real outward foreign direct investment
lgdt            float   %9.0g                 log bilateral gross domestic product
lsimi           float   %9.0g                 log similarity in country size
lrk             float   %9.0g                 log relative physical capital endowment
lrh             float   %9.0g                 log relative human capital endowment
lrl             float   %9.0g                 log relative labor endowment
ldist           float   %9.0g                 log geographical distance
lkgdt           float   %9.0g                 = lgdt * abs(lrk)
lkldist         float   %9.0g                 = ldist * (lrk - lrl)
id              int     %9.0g                 group(codeim ind)
------------------------------------------------------------------------------------------
Sorted by: id  year
```

First-stage system GMM estimation

```
. xtseqreg L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl, twostep vce(robust) ///
> gmmiv(L.lrfdi, lag(1 5) collapse model(difference)) ///
> gmmiv(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse model(difference)) ///
> iv(L.lrfdi, difference model(level)) ///
> iv(lkldist lgdt lkgdt lsimi lrk lrh lrl, difference model(level))

Group variable: id                              Number of obs        =      2198
Time variable: year                             Number of groups     =       337

                                                Obs per group:   min =         1
                                                                 avg =  6.522255
                                                                 max =        10

                                                Number of instruments =       49

                                          (Std. Err. adjusted for clustering on id)
------------------------------------------------------------------------------
             |              WC-Robust
       lrfdi |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lrfdi |
         L1. |   .8956164    .063313    14.15   0.000     .7715252    1.019708
             |
     lkldist |  -.0978499   .1490779    -0.66   0.512    -.3900371    .1943374
        lgdt |  -.1502013   .2320426    -0.65   0.517    -.6049964    .3045939
       lkgdt |   .0072154   .0053281     1.35   0.176    -.0032276    .0176584
       lsimi |   .3100215   .2370884     1.31   0.191    -.1546632    .7747062
         lrk |   .7471581   1.291878     0.58   0.563    -1.784877    3.279193
         lrh |  -.0897363   .1311771    -0.68   0.494    -.3468386    .1673661
         lrl |  -.8973519    1.30242    -0.69   0.491    -3.450048    1.655344
       _cons |   4.926161   5.971464     0.82   0.409    -6.777694    16.63002
------------------------------------------------------------------------------

. estimates store gmm1
```

First-stage system GMM estimation

```
. estat serial, ar(1/3)

Arellano-Bond test for autocorrelation of the first-differenced residuals
H0: no autocorrelation of order 1:      z =   -7.3012   Prob > |z|  =    0.0000
H0: no autocorrelation of order 2:      z =   -0.0535   Prob > |z|  =    0.9573
H0: no autocorrelation of order 3:      z =   -0.3725   Prob > |z|  =    0.7095

. estat overid

Hansen's J-test                                         chi2(40)    =   45.7042
H0: overidentifying restrictions are valid              Prob > chi2 =    0.2471
```

- Replication with `xtabond2`:

```
. xtabond2 L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl, twostep robust ar(3) ///
>  gmm(lrfdi, lag(2 6) collapse equation(diff)) ///
>  gmm(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse equation(diff)) ///
>  iv(LD.lrfdi, equation(level) mz) ///
>  iv(D.lkldist D.lgdt D.lkgdt D.lsimi D.lrk D.lrh D.lrl, equation(level) mz)

------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -6.69  Pr > z =  0.000
Arellano-Bond test for AR(2) in first differences: z =  -0.05  Pr > z =  0.957
Arellano-Bond test for AR(3) in first differences: z =  -0.37  Pr > z =  0.709
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(40)    =  80.12  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(40)    =  45.70  Prob > chi2 =  0.247
  (Robust, but weakened by many instruments.)
```

How (not) to do xtabond2: Always double check!

- The first two specifications yield identical estimation results. The results from the last specification differ (but should not):

```
. xtseqreg L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl, twostep vce(robust) ///
>  gmmiv(L.lrfdi, lag(1 5) collapse model(difference)) ///
>  gmmiv(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse model(difference)) ///
>  iv(L.lrfdi, difference model(level)) ///
>  iv(lkldist lgdt lkgdt lsimi lrk lrh lrl, difference model(level))
```

```
. xtabond2 L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl, twostep robust ar(3) ///
>  gmm(lrfdi, lag(2 6) collapse equation(diff)) ///
>  gmm(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse equation(diff)) ///
>  iv(LD.lrfdi, equation(level) mz) ///
>  iv(D.lkldist D.lgdt D.lkgdt D.lsimi D.lrk D.lrh D.lrl, equation(level) mz)
```

```
. xtabond2 L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl, twostep robust ar(3) ///
>  gmm(L.lrfdi, lag(1 5) collapse equation(diff)) ///
>  gmm(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse equation(diff)) ///
>  iv(LD.lrfdi, equation(level) mz) ///
>  iv(D.lkldist D.lgdt D.lkgdt D.lsimi D.lrk D.lrh D.lrl, equation(level) mz)
```

Second-stage 2SLS estimation

```
. xtseqreg lrfdi (L.lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl) ldist, vce(robust) ///
> first(gmm1, nocons) iv(lsimi lrh)

Group variable: id                          Number of obs       =      2198
Time variable: year                         Number of groups    =       337

------------------------------------------------------------------------------
Equation _first                             Equation _second
Number of obs         =      2198           Number of obs       =      2198
Number of groups      =       337           Number of groups    =       337

Obs per group:    min =         1           Obs per group:    min =         1
                  avg =  6.522255                             avg =  6.522255
                  max =        10                             max =        10

Number of instruments =        49           Number of instruments =         3

                                  (Std. Err. adjusted for clustering on id)
------------------------------------------------------------------------------
             |               Robust
       lrfdi |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_first       |
       lrfdi |
         L1. |   .8956164    .063313    14.15   0.000     .7715252    1.019708
             |
     lkldist |  -.0978499   .1490779    -0.66   0.512    -.3900371    .1943374
        lgdt |  -.1502013   .2320426    -0.65   0.517    -.6049964    .3045939
       lkgdt |   .0072154   .0053281     1.35   0.176    -.0032276    .0176584
       lsimi |   .3100215   .2370884     1.31   0.191    -.1546632    .7747062
         lrk |   .7471581   1.291878     0.58   0.563    -1.784877    3.279193
         lrh |  -.0897363   .1311771    -0.68   0.494    -.3468386    .1673661
         lrl |  -.8973519    1.30242    -0.69   0.491    -3.450048    1.655344
-------------+----------------------------------------------------------------
_second      |
       ldist |  -.1213967   .5854263    -0.21   0.836    -1.268811    1.026018
       _cons |   5.966496     8.5777     0.70   0.487    -10.84549    22.77848
------------------------------------------------------------------------------
```

Second-stage 2SLS estimation

```
. estat overid

Hansen's J-test for equation _first                     chi2(40)     =   45.7042
H0: overidentifying restrictions are valid              Prob > chi2 =    0.2471

Hansen's J-test for equation _second                    chi2(1)      =    1.1989
H0: overidentifying restrictions are valid              Prob > chi2 =    0.2735
```

- Replication with `ivregress` (incorrect standard errors):

```
. quietly estimates restore gmm1

. quietly predict residuals, ue

. ivregress 2sls residuals (ldist = lsimi lrh), vce(cluster id)

Instrumental variables (2SLS) regression          Number of obs     =      2,198
                                                  Wald chi2(1)      =       2.15
                                                  Prob > chi2       =     0.1422
                                                  R-squared         =     0.0107
                                                  Root MSE          =     .46723

                                  (Std. Err. adjusted for 337 clusters in id)
------------------------------------------------------------------------------
             |               Robust
   residuals |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ldist |  -.1213967   .0827107    -1.47   0.142    -.2835066    .0407132
       _cons |   1.040335   .7110881     1.46   0.143    -.3533725    2.434042
------------------------------------------------------------------------------
Instrumented:  ldist
Instruments:   lsimi lrh
```

One-stage GMM estimation

```
. xtseqreg L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl ldist, twostep vce(robust) ///
> gmmiv(L.lrfdi, lag(1 5) collapse model(difference)) ///
> gmmiv(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse model(difference)) ///
> iv(L.lrfdi, difference model(level)) ///
> iv(lkldist lgdt lkgdt lsimi lrk lrh lrl, difference model(level)) ///
> iv(lsimi lrh)

Group variable: id                            Number of obs         =      2198
Time variable: year                           Number of groups      =       337

                                              Obs per group:    min =         1
                                                                avg =  6.522255
                                                                max =        10

                                              Number of instruments =        51

                                      (Std. Err. adjusted for clustering on id)
```

lrfdi	Coef.	WC-Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
lrfdi						
L1.	.874835	.0658537	13.28	0.000	.7457641	1.003906
lkldist	-.0894573	.1552895	-0.58	0.565	-.3938191	.2149044
lgdt	-.100095	.2389068	-0.42	0.675	-.5683437	.3681537
lkgdt	.0103749	.0053781	1.93	0.054	-.000166	.0209159
lsimi	.3735686	.2467129	1.51	0.130	-.1099798	.8571171
lrk	.6246915	1.349609	0.46	0.643	-2.020494	3.269877
lrh	-.0007819	.1125051	-0.01	0.994	-.2212878	.2197241
lrl	-.7648876	1.37943	-0.55	0.579	-3.468521	1.938746
ldist	-.0825973	.1385583	-0.60	0.551	-.3541665	.1889719
_cons	4.320648	6.06585	0.71	0.476	-7.5682	16.2095

```
. estat hausman gmm1 (L.lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl)

Generalized Hausman test                              chi2(1)      =    4.4792
H0: coefficients do not systematically differ         Prob > chi2  =    0.0343
```

How (not) to do xtabond2: Remember the assumptions!

```
. estat overid gmm1

Difference-in-Hansen test                              chi2(1)      =    2.6932
H0: overidentifying restrictions are valid             Prob > chi2 =    0.1008
```

- Instruments for the first-differenced equation are uncorrelated with time-invariant variables by construction, first-differenced instruments for the level equation by assumption.

$\Rightarrow$ Difference-in-Hansen tests might be based on asymptotically incorrect (or at least debatable) degrees of freedom:

```
. xtabond2 L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl ldist, twostep robust ///
>  gmm(lrfdi, lag(2 6) collapse equation(diff)) ///
>  gmm(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse equation(diff)) ///
>  iv(LD.lrfdi, equation(level) mz) ///
>  iv(D.lkldist D.lgdt D.lkgdt D.lsimi D.lrk D.lrh D.lrl, equation(level) mz) ///
>  iv(lsimi lrh, equation(level) mz)


Difference-in-Hansen tests of exogeneity of instrument subsets:

  iv(lsimi lrh, mz eq(level))
    Hansen test excluding group:      chi2(39)    =  45.95  Prob > chi2 =  0.206
    Difference (null H = exogenous): chi2(2)     =   2.44  Prob > chi2 =  0.295
```

Alternative first-stage QML estimator

- First-stage QML estimator of Hsiao et al. (2002):

```
. quietly xtdpdqml lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl, fe mlparam vce(robust)

. xtseqreg lrfdi (L.lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl) ldist, vce(robust) ///
>  first(, nocons) iv(lsimi lrh) noheader
note: first-stage variable names do not match with coefficient list from xtdpdqml
note: dependent variable D.lrfdi from xtdpdqml does not match with lrfdi

                              (Std. Err. adjusted for clustering on id)
------------------------------------------------------------------------------
             |               Robust
       lrfdi |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_first       |
       lrfdi |
         L1. |   .8000757   .0539962    14.82   0.000     .6942451    .9059062
             |
     lkldist |  -.7160072   .5053811    -1.42   0.157    -1.706536    .2745216
        lgdt |   .4346637   .1907476     2.28   0.023     .0608052    .8085221
       lkgdt |   .0028906   .0068807     0.42   0.674    -.0105954    .0163766
       lsimi |   .3172032   .3605734     0.88   0.379    -.3895076    1.023914
         lrk |   6.152142   4.400668     1.40   0.162    -2.473009    14.77729
         lrh |   .0758457   .0869135     0.87   0.383    -.0945017    .2461931
         lrl |   -5.60704   4.175718    -1.34   0.179     -13.7913    2.577216
-------------+----------------------------------------------------------------
_second      |
       ldist |    2.41061   2.285819     1.05   0.292    -2.069514    6.890734
       _cons |  -31.43894   21.15977    -1.49   0.137    -72.91133    10.03345
------------------------------------------------------------------------------

. estat overid

Hansen's J-test for equation _second                 chi2(1)     =    0.8358
H0: overidentifying restrictions are valid           Prob > chi2 =    0.3606
```

Alternative first-stage GMM estimator

- First-stage GMM estimator of Ahn and Schmidt (1995):

```
. quietly xtdpdgmm L(0/1).lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl, twostep noserial ///
> vce(robust) aux gmmiv(L.lrfdi, lag(1 5) collapse model(difference)) ///
> gmmiv(lkldist lgdt lkgdt lsimi lrk lrh lrl, lag(0 4) collapse model(difference))

. xtseqreg lrfdi (L.lrfdi lkldist lgdt lkgdt lsimi lrk lrh lrl) ldist, vce(robust) ///
> first(, copy) iv(lsimi lrh) noheader
note: first-stage standard errors may not be robust

                              (Std. Err. adjusted for clustering on id)
------------------------------------------------------------------------------
             |               Robust
       lrfdi |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_first       |
       lrfdi |
         L1. |   .8017069   .1204806     6.65   0.000     .5655692    1.037845
             |
     lkldist |  -.2290635   .7040092    -0.33   0.745    -1.608896    1.150769
        lgdt |  -.0748559   .2905325    -0.26   0.797    -.6442891    .4945773
       lkgdt |  -.0186638   .0112666    -1.66   0.098    -.0407459    .0034183
       lsimi |   .0212282   .3722118     0.06   0.955    -.7082936      .75075
         lrk |   1.784527   6.101738     0.29   0.770    -10.17466    13.74371
         lrh |   .0299533   .1551918     0.19   0.847    -.2742171    .3341238
         lrl |  -1.580551   6.123368    -0.26   0.796    -13.58213    10.42103
       _cons |   3.642671   7.335562     0.50   0.619    -10.73477    18.02011
-------------+----------------------------------------------------------------
_second      |
       ldist |   .3209373   1.580573     0.20   0.839    -2.776928    3.418803
       _cons |  -2.761592   13.56865    -0.20   0.839    -29.35565    23.83247
------------------------------------------------------------------------------

. estat overid

Hansen's J-test for equation _second                   chi2(1)      =    2.7079
H0: overidentifying restrictions are valid             Prob > chi2  =    0.0999
```

Time effects

```
. xtseqreg L(0/1).lrfdi, teffects twostep vce(robust) ///
> gmmiv(L.lrfdi, lag(1 5) collapse model(difference)) iv(L.lrfdi, difference model(level))

Group variable: id                          Number of obs         =      2198
Time variable: year                         Number of groups      =       337

                                            Obs per group:   min =         1
                                                             avg =  6.522255
                                                             max =        10

                                            Number of instruments =        16

                                     (Std. Err. adjusted for clustering on id)
------------------------------------------------------------------------------
             |              WC-Robust
       lrfdi |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lrfdi |
         L1. |   1.015676   .0727146    13.97   0.000     .8731579    1.158194
             |
        year |
        1991 |  -.0975429   .0419594    -2.32   0.020    -.1797819   -.0153039
        1992 |  -.0670002   .0476785    -1.41   0.160    -.1604484    .0264479
        1993 |  -.0945048   .0457007    -2.07   0.039    -.1840766   -.0049331
        1994 |  -.0644637   .0701426    -0.92   0.358    -.2019406    .0730132
        1995 |  -.0513381   .0426408    -1.20   0.229    -.1349125    .0322363
        1996 |  -.0605227   .0481965    -1.26   0.209    -.1549861    .0339408
        1997 |  -.1211606   .0594696    -2.04   0.042    -.2377189   -.0046024
        1998 |  -.1699316   .0552347    -3.08   0.002    -.2781895   -.0616736
        1999 |  -.1261552   .0830178    -1.52   0.129    -.2888672    .0365568
             |
       _cons |   .0937689   .3189754     0.29   0.769    -.5314114    .7189492
------------------------------------------------------------------------------

. estat overid

Hansen's J-test                                    chi2(5)     =   13.2885
H0: overidentifying restrictions are valid         Prob > chi2 =    0.0208
```

How (not) to do xtabond2: Beware of the dummy trap!

```
. xtabond2 L(0/1).lrfdi i.year, twostep robust ///
> gmm(lrfdi, lag(2 6) collapse equation(diff)) iv(LD.lrfdi, equation(level) mz) ///
> iv(i.year, equation(level))
```

lrfdi	Coef.	Corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
lrfdi						
L1.	1.015676	.0727146	13.97	0.000	.8731579	1.158194
year						
1989	0	(empty)				
1990	.0644637	.0701426	0.92	0.358	-.0730132	.2019406
1991	-.0330792	.0597255	-0.55	0.580	-.150139	.0839805
1992	-.0025366	.0513121	-0.05	0.961	-.1031064	.0980333
1993	-.0300412	.0579887	-0.52	0.604	-.1436969	.0836146
1994	0	(omitted)				
1995	.0131256	.0551362	0.24	0.812	-.0949394	.1211905
1996	.003941	.055217	0.07	0.943	-.1042823	.1121643
1997	-.056697	.0504278	-1.12	0.261	-.1555337	.0421398
1998	-.1054679	.04837	-2.18	0.029	-.2002714	-.0106643
1999	-.0616915	.0540627	-1.14	0.254	-.1676525	.0442694
_cons	.0293052	.3703467	0.08	0.937	-.696561	.7551714

```
Hansen test of overid. restrictions: chi2(3)    =  13.29  Prob > chi2 =  0.004
  (Robust, but weakened by many instruments.)
```

How (not) to do xtabond2: Always specify equation()!

- Instruments for the time dummies should only be included for the level equation. Asymptotically, the additional instruments for the first-differenced equation are redundant.

⇒ Hansen's J-test is based on incorrect degrees of freedom:

```
. xtabond2 L(0/1).lrfdi i.year, twostep robust ///
> gmm(lrfdi, lag(2 6) collapse equation(diff)) iv(LD.lrfdi, equation(level) mz) ///
> iv(i.year, equation(diff)) iv(i.year, equation(level))


Hansen test of overid. restrictions: chi2(12)   =  14.82  Prob > chi2 =  0.252
  (Robust, but weakened by many instruments.)
```

- Never use the `iv()` option without suboption `equation()`! It is not equivalent to the joint specification of `iv(, equation(diff))` and `iv(, equation(level))`:

```
. xtabond2 L(0/1).lrfdi i.year, twostep robust ///
> gmm(lrfdi, lag(2 6) collapse equation(diff)) iv(LD.lrfdi, equation(level) mz) ///
> iv(i.year)


Hansen test of overid. restrictions: chi2(3)    =  10.79  Prob > chi2 =  0.013
  (Robust, but weakened by many instruments.)
```

Summary: the new `xtseqreg` package for Stata

- Sequential estimation can provide partial robustness to model misspecification.
- Is is important to compute corrected standard errors at the second stage that account for the first-stage estimation error.
- The new `xtseqreg` Stata command implements this standard error correction for two-stage linear panel data models.
- The two-stage procedure is particularly relevant in the presence of time-invariant regressors, but it can be easily applied to more general settings.

Kripfganz, S., and C. Schwarz (2015). Estimation of linear dynamic panel data models with time-invariant regressors. *ECB Working Paper 1838*. European Central Bank.

`net install xtseqreg, from(http://www.kripfganz.de/stata/)` or `ssc install xtseqreg`

```
help xtseqreg
help xtseqreg postestimation
```

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