xtdpdqml: Quasi-maximum likelihood estimation of linear dynamic short-T panel data models

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```
net install xtdpdqml, from(http://www.kripfganz.de/stata/)
```

Estimation of short-T linear dynamic panel models in Stata

- Least-squares estimation of dynamic models (i.e. models with a lagged dependent variable) with random or fixed effects (`xtreg` in Stata) yields biased coefficient estimates when the time horizon is short (Nickell, 1981).
- Predominent estimation technique in empirical research is the generalized method of moments (GMM):
  - Arellano and Bond (1991) "difference GMM": `xtabond`,
  - Arellano and Bover (1995) and Blundell and Bond (1998) "system GMM": `xtdpdsys`.

  ⇒ Both Stata commands are wrappers for the more flexible command `xtdpd`.

  ⇒ Alternative user-written command with full flexibility and many additional options by Roodman (2009): `xtabond2`.

Estimation of short-T linear dynamic panel models in Stata

- Other promising approaches that can be more efficient alternatives to GMM with potentially better finite-sample performance remain underrepresented in empirical work:
  - Bias-correction procedures by Kiviet (1995), Bun and Kiviet (2003), and Everaert and Pozzi (2007): user-written implementations `xtlsdvc` (Bruno, 2005) and `xtbcfe` (De Vos, Everaert, and Ruyssen, 2015).
  - Full-information maximum likelihood / structural equation modeling: `xtdpdml` command by Williams, Allison, and Moral-Benito (2015) as a wrapper for `sem`.
  - Limited-information quasi-maximum likelihood (QML) estimation for dynamic random-effects models (Bhargava and Sargan, 1983) and dynamic fixed-effects models (Hsiao, Pesaran, and Tahmiscioglu, 2002): new **`xtdpdqml`** package.

Linear dynamic panel data model

- Linear panel model with first-order autoregressive dynamics:

$$y_{it} = \lambda y_{i,t-1} + \mathbf{x}_{it}'\beta + \mathbf{f}_i'\gamma + \epsilon_{it}, \quad \epsilon_{it} = u_i + e_{it},$$

  $t = 1, 2, \dots, T_i$ (potentially unbalanced but without gaps), and where $e_{it} \overset{iid}{\sim} (0, \sigma_e^2)$. The regressors $\mathbf{x}_{it}$ and $\mathbf{f}_i$ are required to be strictly exogenous with respect to e_{it}.
- The lagged dependent variable $y_{i,t-1}$ is correlated by construction with the unit-specific error component u_i.
- Dynamic random-effects model:
  - The time-varying regressors $\mathbf{x}_{it}$ and the time-invariant regressors $\mathbf{f}_i$ are uncorrelated with u_i.
- Dynamic fixed-effects model:
  - All regressors are allowed to be correlated with u_i.

Dynamic random-effects model

$$y_{it} = \lambda y_{i,t-1} + \mathbf{x}_{it}'\beta + \mathbf{f}_i'\gamma + \epsilon_{it}, \quad \epsilon_{it} = u_i + e_{it},$$

- Random-effects assumption:
  - $u_i \overset{iid}{\sim} (0, \sigma_u^2)$, uncorrelated with $\mathbf{x}_{it}$ and $\mathbf{f}_i$.
- The classical random-effects estimator is a least-squares estimator treating the initial observations y_{i0} as exogenous. Consequently, it is biased when T is small due to the correlation of $y_{i,t-1}$ (and therefore also y_{i0}) with u_i.
- To account for this correlation with a likelihood approach, the joint distribution of $(y_{i0}, y_{i1}, \ldots, y_{iT_i})$ needs to be specified.

Dynamic random-effects model

$$y_{it} = \lambda y_{i,t-1} + \mathbf{x}_{it}'\beta + \mathbf{f}_i'\gamma + \epsilon_{it}, \quad \epsilon_{it} = u_i + e_{it},$$

- Bhargava and Sargan (1983) propose to model the initial observations as a function of the observed exogenous variables:

$$y_{i0} = \sum_{s=0}^{T^*} \mathbf{x}_{is}' \boldsymbol{\pi}_{x,s} + \mathbf{f}_i' \boldsymbol{\pi}_f + \nu_{i0},$$

  with $T^* = \min(T_i)$, $Var(\nu_{i0}) = \sigma_0^2$, and $Cov(\nu_{i0}, \epsilon_{it}) = \phi\sigma_0^2$.
- Implied restrictions under stationarity of all variables:
  - $\phi = \frac{\sigma_u^2}{(1-\lambda)\sigma_0^2}$ in the presence of time-varying regressors $\mathbf{x}_{it}$,
  - $\boldsymbol{\pi}_f = \frac{\gamma}{1-\lambda}$, $\sigma_0^2 = \frac{\sigma_u^2}{(1-\lambda)^2} + \frac{\sigma_e^2}{1-\lambda^2}$, and $\phi = \frac{\sigma_u^2}{(1-\lambda)\sigma_0^2}$ in the absence of time-varying regressors $\mathbf{x}_{it}$.

Dynamic fixed-effects model

$$y_{it} = \lambda y_{i,t-1} + \mathbf{x}_{it}'\beta + \mathbf{f}_i'\gamma + \epsilon_{it}, \quad \epsilon_{it} = u_i + e_{it},$$

- Fixed-effects assumption:
  - u_i allowed to be arbitrarily correlated with $\mathbf{x}_{it}$ and $\mathbf{f}_i$.
- First-difference transformation to remove the fixed effects:

$$\Delta y_{it} = \lambda \Delta y_{i,t-1} + \Delta \mathbf{x}_{it}'\beta + \Delta e_{it},$$

- The lagged dependent variable $\Delta y_{i,t-1}$ (and therefore also Δy_{i1}) is correlated by construction with the transformed error term Δe_{it}. Consequently, an estimator that treats Δy_{i1} as exogenous is biased.
- To account for this correlation with a likelihood approach, the joint distribution of $(\Delta y_{i1}, \Delta y_{i2}, \dots, \Delta y_{iT_i})$ needs to be specified.

Dynamic fixed-effects model

$$\Delta y_{it} = \lambda \Delta y_{i,t-1} + \Delta \mathbf{x}'_{it} \beta + \Delta e_{it},$$

- Hsiao, Pesaran, and Tahmiscioglu (2002) justify the following representation for the initial observations:

$$\Delta y_{i1} = b + \sum_{s=1}^{T^*} \Delta \mathbf{x}'_{is} \boldsymbol{\pi}_s + \nu_{i1},$$

  with $T^* = \min(T_i)$, $Var(\nu_{i1}) = \omega \sigma_e^2$, $Cov(\nu_{i0}, \Delta e_{i2}) = -\sigma_e^2$, and $Cov(\nu_{i0}, \Delta e_{it}) = 0$ for $t > 2$.
- Implied restrictions under stationarity of all (first-differenced) variables:
  - $b = 0$ in the presence of regressors $\Delta \mathbf{x}_{it}$,
  - $b = 0$ and $\omega = \frac{2}{1+\lambda}$ in the absence of regressors $\Delta \mathbf{x}_{it}$.

Quasi-maximum likelihood estimation

- Given the assumptions on the error components and treating all of them as if they were normally distributed, the log-likelihood function for the system of equations can be maximized with a gradient-based optimization technique.
- This iterative procedure needs appropriate starting values:[1]
  - By default, `xtdpdqml` obtains initial estimates for the model coefficients from a consistent GMM estimator (`xtdpd`).
  - Initial estimates for the initial-observations coefficients are obtained from a separate least-squares estimation.
  - The initial variance parameter estimates are computed from the respective residuals.
  - Alternative initial estimates for the model coefficients and variance parameters can be specified by the user.
- Analytical first-order and second-order derivatives largely speed up the computations.

[1] See the paper and the online appendix at `www.kripfganz.de` for details.

Stata syntax of the `xtdpdqml` command

`xtdpdqml` *depvar* [*indepvars*] [*if*] [*in*] [, *options*]

- Selected options:
  - `fe`: uses the fixed-effects estimator, the default,
  - `re`: uses the random-effects estimator,
  - `projection(`*varlist* `[, leads(#) nodifference omit])`: specifies the initial-observations projection,
  - `stationary`: imposes restrictions valid under stationarity,
  - `vce(robust)`: uses the sandwich VC estimator for valid inference under cross-sectional heteroskedasticity (Hayakawa and Pesaran, 2015),
  - `mlparams`: reports all ML parameter estimates,
  - `from(`*init_specs*`)` and `initval(`*numlist*`)`: specify alternative starting values,
  - additional *display_options*, *maximize_options*, ...
- Selected postestimation commands:
  - `predict`: similar to `xtreg` plus equation-level scores,
  - `estat`, `hausman`, `lrtest`, `nlcom`, `suest`, `test`, ...

Example

- Estimation of an employment equation for 140 UK companies, 1976–1984, based on the Arellano and Bond (1991) data set:

```
. webuse abdata
```

- Dependent variable:
  - Logarithm of the number of employees (`n`).
- Strictly exogenous explanatory variables:
  - Real wage (`w`),
  - Gross capital stock (`k`),
  - Time dummies (`yr1978`-`yr1984`).

Example

- QML estimation of the dynamic fixed-effects model:

```
. xtdpdqml n w k yr1978-yr1984, nolog

Quasi-maximum likelihood estimation

Group variable: id                          Number of obs        =       891
Time variable: year                         Number of groups     =       140

Fixed effects                               Obs per group:   min =         6
                                                             avg =  6.364286
(Estimation in first differences)                            max =         8
------------------------------------------------------------------------------
           n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           n |
         L1. |   .7181159   .0349792    20.53   0.000     .6495579    .7866738
             |
           w |  -.4210157   .0512701    -8.21   0.000    -.5215034   -.3205281
           k |   .2487324   .0255407     9.74   0.000     .1986736    .2987911
      yr1978 |  -.0214489   .0149487    -1.43   0.151    -.0507478      .00785
      yr1979 |  -.0319754   .0149372    -2.14   0.032    -.0612518   -.0026991
      yr1980 |  -.0637126   .0148821    -4.28   0.000     -.092881   -.0345441
      yr1981 |  -.1130657   .0150739    -7.50   0.000      -.14261   -.0835213
      yr1982 |  -.0844508   .0160798    -5.25   0.000    -.1159666    -.052935
      yr1983 |  -.0461928   .0197008    -2.34   0.019    -.0848057   -.0075798
      yr1984 |  -.0115354   .0241271    -0.48   0.633    -.0588236    .0357528
       _cons |    1.74826   .1705756    10.25   0.000     1.413938    2.082582
------------------------------------------------------------------------------
```

Example

- Reporting of all parameter estimates:

```
. xtdpdqml n w k yr1978-yr1984, mlparams nolog

Quasi-maximum likelihood estimation

Group variable: id                          Number of obs        =       891
Time variable: year                         Number of groups     =       140

Fixed effects                               Obs per group:   min =         6
                                                             avg =  6.364286
                                                             max =         8
------------------------------------------------------------------------------
         D.n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_model       |
           n |
         LD. |   .7181159   .0349792    20.53   0.000     .6495579    .7866738
             |
           w |
         D1. |  -.4210157   .0512701    -8.21   0.000    -.5215034   -.3205281
             |
           k |
         D1. |   .2487324   .0255407     9.74   0.000     .1986736    .2987911
             |
      yr1978 |
         D1. |  -.0214489   .0149487    -1.43   0.151    -.0507478      .00785
             |
```

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Example

```
      yr1979 |
         D1. |  -.0319754   .0149372    -2.14   0.032    -.0612518   -.0026991
             |
      yr1980 |
         D1. |  -.0637126   .0148821    -4.28   0.000     -.092881   -.0345441
             |
      yr1981 |
         D1. |  -.1130657   .0150739    -7.50   0.000      -.14261   -.0835213
             |
      yr1982 |
         D1. |  -.0844508   .0160798    -5.25   0.000    -.1159666    -.052935
             |
      yr1983 |
         D1. |  -.0461928   .0197008    -2.34   0.019    -.0848057   -.0075798
             |
      yr1984 |
         D1. |  -.0115354   .0241271    -0.48   0.633    -.0588236    .0357528
-------------+----------------------------------------------------------------
_initobs     |
           w |
         D1. |   .1745629   .0835193     2.09   0.037      .010868    .3382578
         FD. |   .4866594   .1160984     4.19   0.000     .2591107     .714208
        F2D. |    .234992   .0921914     2.55   0.011     .0543001    .4156838
        F3D. |    .180422   .0831649     2.17   0.030     .0174218    .3434222
        F4D. |   .1587507   .0822884     1.93   0.054    -.0025316    .3200329
        F5D. |   .1828358   .0801948     2.28   0.023      .025657    .3400147
             |
(Continued on next page)
```

Example

```
           k |
         D1. |   .2516903   .0514379     4.89   0.000     .1508739    .3525068
         FD. |  -.0759983   .0442764    -1.72   0.086    -.1627784    .0107819
        F2D. |   .0345647   .0402481     0.86   0.390    -.0443201    .1134496
        F3D. |   .0426643   .0416536     1.02   0.306    -.0389754    .1243039
        F4D. |   .0180357   .0354471     0.51   0.611    -.0514394    .0875108
        F5D. |   .1373772   .0420249     3.27   0.001     .0550099    .2197445
             |
      yr1978 |
         D1. |   .0472505   .0347851     1.36   0.174    -.0209269     .115428
         FD. |   .0336196   .0205327     1.64   0.102    -.0066237     .073863
             |
       _cons |   .0034106   .0211468     0.16   0.872    -.0380363    .0448575
-------------+----------------------------------------------------------------
   /_sigma2e |   .0107403   .0005952                      .0095737     .011907
     /_omega |   1.219196   .0690326                      1.083894    1.354497
------------------------------------------------------------------------------

. estimates store fe
```

Example

- Restricted model versions:

```
. xtdpdqml n w k yr1978-yr1984, stationary mlparams nolog
(Output omitted)

. lrtest fe

Likelihood-ratio test                                 LR chi2(1)  =      0.03
(Assumption: . nested in fe)                          Prob > chi2 =    0.8720

. xtdpdqml n w k yr1978-yr1984, stationary projection(yr*, omit) mlparams nolog
(Output omitted)

. lrtest fe

Likelihood-ratio test                                 LR chi2(3)  =      6.29
(Assumption: . nested in fe)                          Prob > chi2 =    0.0983

. estimates restore fe
(results fe are active now)

. test [_initobs]: D.yr1978 FD.yr1978 _cons

 ( 1)  [_initobs]D.yr1978 = 0
 ( 2)  [_initobs]FD.yr1978 = 0
 ( 3)  [_initobs]_cons = 0

           chi2(  3) =    6.36
         Prob > chi2 =    0.0955
```

Example

```
. xtdpdqml n w k yr1978-yr1984, stationary projection(w k, leads(0)) mlparams nolog
(Output omitted)

. lrtest fe

Likelihood-ratio test                                 LR chi2(11) =     42.49
(Assumption: . nested in fe)                          Prob > chi2 =    0.0000
```

- Alternative starting values from "system GMM" estimator (default starting values are from "difference GMM" estimator):

```
. quietly xtdpdsys n w k yr1978-yr1984, twostep

. matrix b = e(b)

. xtdpdqml n w k yr1978-yr1984, stationary from(b, skip)
(Output omitted)

. estimates store fe
```

Example

- QML estimation of the dynamic random-effects model:

```
. xtdpdqml n w k yr1978-yr1984, re nolog

Quasi-maximum likelihood estimation
initial values not feasible
```

- Feasible starting values for the variance parameters $(\sigma_u^2, \sigma_e^2, \sigma_0^2, \phi)$ need to satisfy the restriction

$$(\sigma_u^2 - \phi^2 \sigma_0^2) \max(T_i) > -\sigma_e^2.$$

```
. xtdpdqml n w k yr1978-yr1984, re initval(.1 .2 .2 .3) nolog
(Output omitted)

. estimates store re
```

Example

- Traditional Hausman test:

```
. hausman fe re, df(3)

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fe_eq1       re_eq1       Difference          S.E.
-------------+----------------------------------------------------------------
           n |
         L1. |    .7175701     .6827449        .0348253        .0226022
           w |   -.4219682     -.304499       -.1174692        .0284715
           k |    .2493912     .2630639       -.0136728        .0131214
      yr1978 |   -.0212959    -.0215183        .0002224        .0016011
      yr1979 |   -.0317929    -.0326742        .0008813        .0015725
      yr1980 |   -.0633101    -.0639498        .0006397               .
      yr1981 |   -.1125881    -.1171753        .0045871               .
      yr1982 |   -.0839164    -.0953542        .0114378        .0042314
      yr1983 |   -.0455604    -.0651054         .019545         .006765
      yr1984 |   -.0107753     -.035986        .0252107        .0069979
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from xtdpdqml
           B = inconsistent under Ha, efficient under Ho; obtained from xtdpdqml

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      240.26
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Example

- Generalized (robust) Hausman test:

```
. quietly xtdpdqml n w k yr1978-yr1984, mlparams

. estimates store fe

. quietly xtdpdqml n w k yr1978-yr1984, re initval(.1 .2 .2 .3) mlparams

. estimates store re

. suest fe re, vce(cluster id)

Simultaneous results for fe, re

                                                Number of obs     =      1,031

                                  (Std. Err. adjusted for 140 clusters in id)
------------------------------------------------------------------------------
             |               Robust
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
fe__model    |
           n |
         LD. |   .7181159   .0806002     8.91   0.000     .5601424    .8760893
             |
           w |
         D1. |  -.4210157   .1316838    -3.20   0.001    -.6791113   -.1629202
             |
```

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Example

```
           k |
         D1. |   .2487324    .047906     5.19   0.000     .1548384    .3426263
             |
      yr1978 |
         D1. |  -.0214489   .0142647    -1.50   0.133    -.0494072    .0065095
             |
      yr1979 |
         D1. |  -.0319754    .016767    -1.91   0.057    -.0648382    .0008873
             |
      yr1980 |
         D1. |  -.0637126   .0180549    -3.53   0.000    -.0990996   -.0283255
             |
      yr1981 |
         D1. |  -.1130657   .0209338    -5.40   0.000    -.1540952   -.0720362
             |
      yr1982 |
         D1. |  -.0844508   .0190163    -4.44   0.000     -.121722   -.0471796
             |
      yr1983 |
         D1. |  -.0461928   .0209038    -2.21   0.027    -.0871635    -.005222
             |
      yr1984 |
         D1. |  -.0115354     .02833    -0.41   0.684    -.0670612    .0439905
-------------+----------------------------------------------------------------
```

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Example

```
fe__initobs  |
           w |
         D1. |   .1745629   .0898936     1.94   0.052    -.0016253    .3507512
         FD. |   .4866594   .1895771     2.57   0.010     .1150951    .8582237
        F2D. |    .234992   .1322934     1.78   0.076    -.0242983    .4942823
        F3D. |    .180422   .1104639     1.63   0.102    -.0360833    .3969272
        F4D. |   .1587507   .0902785     1.76   0.079     -.018192    .3356933
        F5D. |   .1828358   .0940585     1.94   0.052    -.0015154    .3671871
             |
           k |
         D1. |   .2516903    .078033     3.23   0.001     .0987485    .4046322
         FD. |  -.0759983   .0668488    -1.14   0.256    -.2070196     .055023
        F2D. |   .0345647   .0385317     0.90   0.370    -.0409561    .1100856
        F3D. |   .0426643   .0470128     0.91   0.364    -.0494791    .1348077
        F4D. |   .0180357   .0278761     0.65   0.518    -.0366004    .0726719
        F5D. |   .1373772   .0447742     3.07   0.002     .0496213    .2251331
             |
      yr1978 |
         D1. |   .0472505   .0210911     2.24   0.025     .0059127    .0885884
         FD. |   .0336196   .0155646     2.16   0.031     .0031136    .0641256
             |
       _cons |   .0034106   .0205965     0.17   0.868    -.0369577    .0437789
-------------+----------------------------------------------------------------
fe__sigma2e  |
       _cons |   .0107403   .0014299     7.51   0.000     .0079379    .0135428
-------------+----------------------------------------------------------------
fe__omega    |
       _cons |   1.219196   .0819172    14.88   0.000     1.058641    1.379751
-------------+----------------------------------------------------------------
```

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Example

```
re__model    |
           n |
         L1. |   .6827449   .0631622    10.81   0.000     .5589492    .8065406
             |
           w |   -.304499   .1153329    -2.64   0.008    -.5305473   -.0784507
           k |   .2630639   .0511424     5.14   0.000     .1628267    .3633012
      yr1978 |  -.0215183   .0141391    -1.52   0.128    -.0492304    .0061938
      yr1979 |  -.0326742   .0160256    -2.04   0.041    -.0640839   -.0012645
      yr1980 |  -.0639498   .0177469    -3.60   0.000    -.0987331   -.0291664
      yr1981 |  -.1171753   .0216733    -5.41   0.000    -.1596542   -.0746964
      yr1982 |  -.0953542   .0222249    -4.29   0.000    -.1389142   -.0517943
      yr1983 |  -.0651054   .0240963    -2.70   0.007    -.1123333   -.0178774
      yr1984 |   -.035986   .0317191    -1.13   0.257    -.0981542    .0261823
       _cons |    1.43717   .4311311     3.33   0.001     .5921688    2.282172
-------------+----------------------------------------------------------------
re__initobs  |
           w |
         --. |   .4486646   .2996806     1.50   0.134    -.1386987    1.036028
         F1. |  -.0795423   .5469361    -0.15   0.884    -1.151517    .9924327
         F2. |  -.8357704   .5370137    -1.56   0.120    -1.888298    .2167572
         F3. |  -.1347361   .3832975    -0.35   0.725    -.8859854    .6165132
         F4. |   .1016144   .3492035     0.29   0.771    -.5828119    .7860408
         F5. |   .1846765   .1168485     1.58   0.114    -.0443424    .4136954
         F6. |  -.5300617   .2599228    -2.04   0.041    -1.039501   -.0206224
             |
```

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Example

```
           k |
         --. |   .8302629   .1898999     4.37   0.000     .4580658     1.20246
         F1. |  -.2463192   .2770439    -0.89   0.374    -.7893152    .2966768
         F2. |   .3583677   .2750527     1.30   0.193    -.1807258    .8974611
         F3. |   .0512604   .1811207     0.28   0.777    -.3037297    .4062505
         F4. |  -.1772404   .2013611    -0.88   0.379    -.5719008      .21742
         F5. |    .470898   .1744223     2.70   0.007     .1290366    .8127594
         F6. |  -.4599582   .1731522    -2.66   0.008    -.7993302   -.1205861
             |
      yr1978 |
         F2. |  -.1260256   .1120337    -1.12   0.261    -.3456076    .0935563
             |
      yr1979 |
         F2. |  -.1369898   .0939022    -1.46   0.145    -.3210347     .047055
             |
       _cons |   4.181794    .921414     4.54   0.000     2.375856    5.987733
-------------+----------------------------------------------------------------
re__sigma2u  |
       _cons |   .0248997   .0110377     2.26   0.024     .0032663    .0465331
-------------+----------------------------------------------------------------
re__sigma2e  |
       _cons |   .0106025   .0014872     7.13   0.000     .0076877    .0135174
-------------+----------------------------------------------------------------
re__sigma2e0 |
       _cons |   .3161824    .048807     6.48   0.000     .2205225    .4118423
-------------+----------------------------------------------------------------
re__phi      |
       _cons |   .2688014   .0576002     4.67   0.000     .1559072    .3816957
------------------------------------------------------------------------------
```

Example

```
. test ([fe__model]LD.n = [re__model]L.n) ([fe__model]D.w = [re__model]w) ([fe__model]D.k = [re__model]k)

 ( 1)  [fe__model]LD.n - [re__model]L.n = 0
 ( 2)  [fe__model]D.w - [re__model]w = 0
 ( 3)  [fe__model]D.k - [re__model]k = 0

           chi2(  3) =    5.97
         Prob > chi2 =    0.1132
```

- Computation of long-run effects:

```
. xtdpdqml n w k yr1978-yr1984, stationary vce(robust)
(Output omitted)

. nlcom (_b[w] / (1 - _b[L.n])) (_b[k] / (1 - _b[L.n]))

       _nl_1:  _b[w] / (1 - _b[L.n])
       _nl_2:  _b[k] / (1 - _b[L.n])

------------------------------------------------------------------------------
           n |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |  -1.494064   .4484327    -3.33   0.001    -2.372976   -.6151519
       _nl_2 |   .8830199   .1834742     4.81   0.000      .523417    1.242623
------------------------------------------------------------------------------
```

Summary: the new `xtdpdqml` package for Stata

- (Quasi-)maximum likelihood estimation can be an attractive alternative to widely used GMM estimators with potential efficiency gains and better finite-sample performance.
- The `xtdpdqml` implements the Bhargava and Sargan (1983) random-effects QML estimator and the Hsiao, Pesaran, and Tahmiscioglu (2002) fixed-effects QML estimator for linear dynamic panel data models.
- It provides a complement to Stata's existing estimation toolbox for dynamic panel models that can be valuable to assess the robustness of estimates obtained with different methods.

Kripfganz, S. (forthcoming). xtdpdqml: Quasi-maximum likelihood estimation of linear dynamic short-T panel data models. *Stata Journal (accepted manuscript)*.

```
net install xtdpdqml, from(http://www.kripfganz.de/stata/)
help xtdpdqml
help xtdpdqml postestimation
```

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