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

Sebastian Kripfganz

University of Exeter Business School, Department of Economics, Exeter, UK

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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 (\texttt{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”: \texttt{xtabond},
  - Arellano and Bover (1995) and Blundell and Bond (1998) “system GMM”: \texttt{xtdpdsys}.

  ⇒ Both Stata commands are wrappers for the more flexible command \texttt{xtdpd}.

  ⇒ Alternative user-written command with full flexibility and many additional options by Roodman (2009): \texttt{xtabond2}.
Other promising approaches that can be more efficient alternatives to GMM with potentially better finite-sample performance remain underrepresented in empirical work:

- 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:

\[ y_{it} = \lambda y_{i,t-1} + x_{it}'\beta + f_i'\gamma + \epsilon_{it}, \quad \epsilon_{it} = u_i + e_{it}, \]

\( t = 1, 2, \ldots, T_i \) (potentially unbalanced but without gaps), and where \( e_{it} \overset{iid}{\sim} (0, \sigma^2_e) \). The regressors \( x_{it} \) and \( f_i \) 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 \( x_{it} \) and the time-invariant regressors \( f_i \) are uncorrelated with \( u_i \).

- Dynamic fixed-effects model:
  - All regressors are allowed to be correlated with \( u_i \).
Dynamic random-effects model

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

- Random-effects assumption:
  - \( u_i \overset{iid}{\sim} (0, \sigma_u^2) \), uncorrelated with \( x_{it} \) and \( f_i \).
- 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

\[ y_{it} = \lambda y_{i,t-1} + x'_{it} \beta + f'_{i} \gamma + \epsilon_{it}, \quad \epsilon_{it} = u_{i} + e_{it}, \]

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

\[
y_{i0} = \sum_{s=0}^{T^*} x'_{is} \pi_{x,s} + f'_{i} \pi_{f} + \nu_{i0},
\]

with \( T^* = \min(T_i) \), \( \text{Var}(\nu_{i0}) = \sigma^2_0 \), and \( \text{Cov}(\nu_{i0}, \epsilon_{it}) = \phi \sigma^2_0 \).

- Implied restrictions under stationarity of all variables:
  - \( \phi = \frac{\sigma^2_u}{(1-\lambda)\sigma^2_0} \) in the presence of time-varying regressors \( x_{it} \),
  - \( \pi_f = \frac{\gamma}{1-\lambda}, \sigma^2_0 = \frac{\sigma^2_u}{(1-\lambda)^2} + \frac{\sigma^2_e}{1-\lambda^2}, \) and \( \phi = \frac{\sigma^2_u}{(1-\lambda)\sigma^2_0} \) in the absence of time-varying regressors \( x_{it} \).
Dynamic fixed-effects model

\[ y_{it} = \lambda y_{i,t-1} + x_{it}' \beta + f_i' \gamma + \epsilon_{it}, \quad \epsilon_{it} = u_i + e_{it}, \]

- Fixed-effects assumption:
  - \( u_i \) allowed to be arbitrarily correlated with \( x_{it} \) and \( f_i \).
- First-difference transformation to remove the fixed effects:
  \[ \Delta y_{it} = \lambda \Delta y_{i,t-1} + \Delta x_{it}' \beta + \Delta e_{it}, \]
- The lagged dependent variable \( \Delta y_{i,t-1} \) (and therefore also \( \Delta y_{i1} \)) is correlated by construction with the transformed error term \( \Delta e_{it} \). Consequently, an estimator that treats \( \Delta y_{i1} \) as exogenous is biased.
- To account for this correlation with a likelihood approach, the joint distribution of \( (\Delta y_{i1}, \Delta y_{i2}, \ldots, \Delta y_{iT_i}) \) needs to be specified.
Dynamic fixed-effects model

\[ \Delta y_{it} = \lambda \Delta y_{i,t-1} + \Delta x_{it}' \beta + \Delta e_{it}, \]

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

\[ \Delta y_{i1} = b + \sum_{s=1}^{T^*} \Delta x_{is}' \pi_s + \nu_{i1}, \]

with \( T^* = \min(T_i) \), \( \text{Var}(\nu_{i1}) = \omega \sigma_e^2 \), \( \text{Cov}(\nu_{i0}, \Delta e_{i2}) = -\sigma_e^2 \), and \( \text{Cov}(\nu_{i0}, \Delta e_{it}) = 0 \) for \( t > 2 \).

- Implied restrictions under stationarity of all (first-differenced) variables:
  - \( b = 0 \) in the presence of regressors \( \Delta x_{it} \).
  - \( b = 0 \) and \( \omega = \frac{2}{1+\lambda} \) in the absence of regressors \( \Delta x_{it} \).
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),
**Example**

**QML estimation of the dynamic fixed-effects model:**

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

Quasi-maximum likelihood estimation

Group variable: id  
Time variable: year

Fixed effects  

(Estimation in first differences)  

|    | 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 .0278557 |
|    | 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 |
```

S. Kripfganz (2016)  
`xtdpdqml`: Quasi-maximum likelihood estimation of linear dynamic short-T panel data models
Example

Reporting of all parameter estimates:

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

Quasi-maximum likelihood estimation

<table>
<thead>
<tr>
<th>Group variable: id</th>
<th>Number of obs = 891</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time variable: year</td>
<td>Number of groups = 140</td>
</tr>
</tbody>
</table>

**Fixed effects**

<table>
<thead>
<tr>
<th>Obs per group:</th>
<th>min = 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>avg = 6.364286</td>
<td></td>
</tr>
</tbody>
</table>

| 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 |

(Continued on next page)
### Example

<table>
<thead>
<tr>
<th>yr1979</th>
<th>D1.</th>
<th>-.0319754</th>
<th>.0149372</th>
<th>-2.14</th>
<th>0.032</th>
<th>-.0612518</th>
<th>-.0026991</th>
</tr>
</thead>
<tbody>
<tr>
<td>yr1980</td>
<td>D1.</td>
<td>-.0637126</td>
<td>.0148821</td>
<td>-4.28</td>
<td>0.000</td>
<td>-.092881</td>
<td>-.0345441</td>
</tr>
<tr>
<td>yr1981</td>
<td>D1.</td>
<td>-.1130657</td>
<td>.0150739</td>
<td>-7.50</td>
<td>0.000</td>
<td>-.14261</td>
<td>-.0835213</td>
</tr>
<tr>
<td>yr1982</td>
<td>D1.</td>
<td>-.0844508</td>
<td>.0160798</td>
<td>-5.25</td>
<td>0.000</td>
<td>-.1159666</td>
<td>-.052935</td>
</tr>
<tr>
<td>yr1983</td>
<td>D1.</td>
<td>-.0461928</td>
<td>.0197008</td>
<td>-2.34</td>
<td>0.019</td>
<td>-.0848057</td>
<td>-.0075798</td>
</tr>
<tr>
<td>yr1984</td>
<td>D1.</td>
<td>-.0115354</td>
<td>.0241271</td>
<td>-0.48</td>
<td>0.633</td>
<td>-.0588236</td>
<td>.0357528</td>
</tr>
</tbody>
</table>

\_initobs

<table>
<thead>
<tr>
<th>w</th>
<th>D1.</th>
<th>.1745629</th>
<th>.0835193</th>
<th>2.09</th>
<th>0.037</th>
<th>.010868</th>
<th>.3382578</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD.</td>
<td>.4866594</td>
<td>.1160984</td>
<td>4.19</td>
<td>0.000</td>
<td>.2591107</td>
<td>.714208</td>
<td></td>
</tr>
<tr>
<td>F2D.</td>
<td>.234992</td>
<td>.0921914</td>
<td>2.55</td>
<td>0.011</td>
<td>.0543001</td>
<td>.4156838</td>
<td></td>
</tr>
<tr>
<td>F3D.</td>
<td>.180422</td>
<td>.0831649</td>
<td>2.17</td>
<td>0.030</td>
<td>.0174218</td>
<td>.3434222</td>
<td></td>
</tr>
<tr>
<td>F4D.</td>
<td>.1587507</td>
<td>.0822884</td>
<td>1.93</td>
<td>0.054</td>
<td>-.0025316</td>
<td>.3200329</td>
<td></td>
</tr>
<tr>
<td>F5D.</td>
<td>.1828358</td>
<td>.0801948</td>
<td>2.28</td>
<td>0.023</td>
<td>.025657</td>
<td>.3400147</td>
<td></td>
</tr>
</tbody>
</table>

(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  0.0095737  .011907  
/_omega   1.219196  .0690326  1.083894  1.354497  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
Traditional Hausman test:

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

<table>
<thead>
<tr>
<th></th>
<th>(b)</th>
<th>(B)</th>
<th>(b-B)</th>
<th>sqrt(diag(V_b-V_B))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>fe_eq1</td>
<td>re_eq1</td>
<td>Difference</td>
<td>S.E.</td>
</tr>
<tr>
<td>n</td>
<td>0.7175701</td>
<td>0.6827449</td>
<td>0.0348253</td>
<td>0.0226022</td>
</tr>
<tr>
<td>L1.</td>
<td>-0.4219682</td>
<td>-0.304499</td>
<td>-0.1174692</td>
<td>0.0284715</td>
</tr>
<tr>
<td>w</td>
<td>0.2493912</td>
<td>0.2630639</td>
<td>-0.0136728</td>
<td>0.0131214</td>
</tr>
<tr>
<td>k</td>
<td>-0.0212959</td>
<td>-0.0215183</td>
<td>0.0002224</td>
<td>0.0016011</td>
</tr>
<tr>
<td>yr1978</td>
<td>-0.0317929</td>
<td>-0.0326742</td>
<td>0.0008813</td>
<td>0.0015725</td>
</tr>
<tr>
<td>yr1979</td>
<td>-0.0633101</td>
<td>-0.0639498</td>
<td>0.0006397</td>
<td>.</td>
</tr>
<tr>
<td>yr1980</td>
<td>-0.1125881</td>
<td>-0.1171573</td>
<td>0.0045871</td>
<td>.</td>
</tr>
<tr>
<td>yr1981</td>
<td>-0.0839164</td>
<td>-0.0953542</td>
<td>0.0114378</td>
<td>0.0042314</td>
</tr>
<tr>
<td>yr1982</td>
<td>-0.0455604</td>
<td>-0.0651054</td>
<td>0.019545</td>
<td>0.006765</td>
</tr>
<tr>
<td>yr1983</td>
<td>-0.0107753</td>
<td>-0.035986</td>
<td>0.0252107</td>
<td>0.0069979</td>
</tr>
</tbody>
</table>

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

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

|                      | Coef. | Std. Err. | z     | P>|z|   | [95% Conf. Interval] |
|----------------------|-------|-----------|-------|-------|----------------------|
|                      | Robust|           |       |       |                      |
| fe__model            |       |           |       |       |                      |
| n                   | .7181159 | .0806002   | 8.91  | 0.000 | .5601424   .8760893 |
| LD.                  |       |           |       |       |                      |
| w                   | -.4210157 | .1316838  | -3.20 | 0.001 | -.6791113 -.1629202 |

(Continued on next page)
### Example

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.19</td>
<td>0.000</td>
<td>-1.50</td>
<td>0.133</td>
<td>-1.91</td>
<td>0.057</td>
<td>-3.53</td>
<td>0.000</td>
<td>-5.40</td>
<td>0.000</td>
<td>-4.44</td>
<td>0.000</td>
<td>-2.21</td>
<td>0.027</td>
<td>-0.41</td>
<td>0.684</td>
</tr>
<tr>
<td></td>
<td>.1548384</td>
<td>.3426263</td>
<td>-.0494072</td>
<td>.0065095</td>
<td>-.0648382</td>
<td>.0008873</td>
<td>-.0990996</td>
<td>-.0283255</td>
<td>-.1540952</td>
<td>-.0720362</td>
<td>-.121722</td>
<td>-.0471796</td>
<td>-.0871635</td>
<td>-.005222</td>
<td>.0439905</td>
<td></td>
</tr>
</tbody>
</table>
### Example

**fe__initobs |**

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D1.</td>
<td>.1745629</td>
<td>.0898936</td>
<td>1.94</td>
<td>0.052</td>
<td>-.0016253</td>
<td>.3507512</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FD.</td>
<td>.4866594</td>
<td>.1895771</td>
<td>2.57</td>
<td>0.010</td>
<td>.1150951</td>
<td>.8582237</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F2D.</td>
<td>.234992</td>
<td>.1322934</td>
<td>1.78</td>
<td>0.076</td>
<td>-.0242983</td>
<td>.4942823</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F3D.</td>
<td>.180422</td>
<td>.1104639</td>
<td>1.63</td>
<td>0.102</td>
<td>-.0360833</td>
<td>.3969272</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F4D.</td>
<td>.1587507</td>
<td>.0902785</td>
<td>1.76</td>
<td>0.079</td>
<td>-.018192</td>
<td>.3356933</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F5D.</td>
<td>.1828358</td>
<td>.0940585</td>
<td>1.94</td>
<td>0.052</td>
<td>-.0016253</td>
<td>.3671871</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**| k         |**

<table>
<thead>
<tr>
<th></th>
<th>D1.</th>
<th>.2516903</th>
<th>.078033</th>
<th>3.23</th>
<th>0.001</th>
<th>.0987485</th>
<th>.4046322</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD.</td>
<td>-.0759983</td>
<td>.0668488</td>
<td>-1.14</td>
<td>0.256</td>
<td>-.2070196</td>
<td>.055023</td>
<td></td>
</tr>
<tr>
<td>F2D.</td>
<td>.0345647</td>
<td>.0385317</td>
<td>0.90</td>
<td>0.370</td>
<td>-.0409561</td>
<td>.1100856</td>
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</tr>
<tr>
<td>F3D.</td>
<td>.0426643</td>
<td>.0470128</td>
<td>0.91</td>
<td>0.364</td>
<td>-.0494791</td>
<td>.1348077</td>
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</tr>
<tr>
<td>F4D.</td>
<td>.0180357</td>
<td>.0278761</td>
<td>0.65</td>
<td>0.518</td>
<td>-.0366004</td>
<td>.0726719</td>
<td></td>
</tr>
<tr>
<td>F5D.</td>
<td>.1373772</td>
<td>.0447742</td>
<td>3.07</td>
<td>0.002</td>
<td>.0496213</td>
<td>.2251331</td>
<td></td>
</tr>
</tbody>
</table>

**| yr1978       |**

<table>
<thead>
<tr>
<th></th>
<th>D1.</th>
<th>.0472505</th>
<th>.0210911</th>
<th>2.24</th>
<th>0.025</th>
<th>.0059127</th>
<th>.0885884</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD.</td>
<td>.0336196</td>
<td>.0155646</td>
<td>2.16</td>
<td>0.031</td>
<td>.0031136</td>
<td>.0641256</td>
<td></td>
</tr>
</tbody>
</table>

| _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 |

(Continued on next page)
Example

```
re__model
n
L1. |  .6827449   .0631622   10.81   0.000   .5589492   .8065406
    w |  -.304499   .1153329   -2.64   0.008  -0.5305473  -0.0784507
    k |  .2630639   .0511424    5.14   0.000   .1628267   .3633012
   yr1978 |  -.0215183   .0141391   -1.52   0.128  -0.0492304  -.0012645
   yr1979 |  -.0326742   .0160256   -2.04   0.041  -0.0640839  -.0012645
   yr1980 |  -.0639498   .0177469   -3.60   0.000  -0.0987331  -.0291664
   yr1981 |  -.1171753   .0216733   -5.41   0.000  -0.1596542  -.0746964
   yr1982 |  -.0953542   .0222249   -4.29   0.000  -0.1389142  -.0517943
   yr1983 |  -.0651054   .0240963   -2.70   0.007  -0.1123333  -.0178774
   yr1984 |  -.035986   .0317191   -1.13   0.257  -0.0981542   .0261823
    _cons |  1.43717   .4311311    3.33   0.001   .5921688  2.282172
-------------+----------------------------------------------------------------
re__initobs
w
--. |  .4486646   .2996806    1.50   0.134  -0.1386987   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  -0.8859854   .6165132
 F4. |   .1016144   .3492035    0.29   0.771  -0.5828119   .7860408
 F5. |   .1846765   .1168485    1.58   0.114  -0.0443424   .4136954
 F6. |  -.5300617   .2599228   -2.04   0.041  -1.039501  -.0206224
(Continued on next page)
```
Example

\[
\begin{array}{|l|c|c|c|c|c|c|}
\hline
k & | & 0.8302629 & 0.1898999 & 4.37 & 0.000 & 0.4580658 & 1.20246 \\
\hline
F1 & | & -.2463192 & 0.2770439 & -0.89 & 0.374 & -.7893152 & .2966768 \\
F2 & | & .3583677 & 0.2750527 & 1.30 & 0.193 & -.1807258 & .8974611 \\
F3 & | & .0512604 & 0.1811207 & 0.26 & 0.777 & -.1807258 & .8974611 \\
F4 & | & -.1772404 & 0.1811207 & -0.88 & 0.379 & -.1807258 & .8974611 \\
F5 & | & .470898 & 0.1811207 & 2.70 & 0.007 & .1290366 & .8127594 \\
F6 & | & -.4599582 & 0.1811207 & -2.66 & 0.008 & -.7993302 & -.1205861 \\
\hline
yr1978 & | & | & | & | & | & \\
F2 & | & -.1260256 & 0.1120337 & -1.12 & 0.261 & -.3456076 & .0935563 \\
\hline
yr1979 & | & | & | & | & | & \\
F2 & | & -.1369898 & 0.0939022 & -1.46 & 0.145 & -.3210347 & .047055 \\
\hline
_cons & | & 4.181794 & 0.921414 & 4.54 & 0.000 & 2.375856 & 5.987733 \\
\hline
\hline
re__sigma2u & | & | & | & | & | & \\
_cons & | & .0248997 & .0110377 & 2.26 & 0.024 & .0032663 & .0465331 \\
\hline
re__sigma2e & | & | & | & | & | & \\
_cons & | & .0106025 & .0014872 & 7.13 & 0.000 & .0076877 & .0135174 \\
\hline
re__sigma2e0 & | & | & | & | & | & \\
_cons & | & .3161824 & .048807 & 6.48 & 0.000 & .2205225 & .4118423 \\
\hline
re__phi & | & | & | & | & | & \\
_cons & | & .2688014 & .0576002 & 4.67 & 0.000 & .1559072 & .3816957 \\
\hline
\end{array}
\]
Example

\[
\begin{align*}
(1) & \quad [fe__model]LD.n - [re__model]L.n = 0 \\
(2) & \quad [fe__model]D.w - [re__model]w = 0 \\
(3) & \quad [fe__model]D.k - [re__model]k = 0 \\
\text{ch}i2(3) & = 5.97 \\
\text{Prob} > \text{ch}i2 & = 0.1132
\end{align*}
\]

**Computation of long-run effects:**

\[
\text{. xtdpdqml n w k yr1978-yr1984, stationary vce(robust)}
\]

(Output omitted)

\[
\text{. nlcom (_b[w] / (1 - _b[L.n])) (_b[k] / (1 - _b[L.n]))}
\]

\[
\begin{align*}
_{\text{n1}_1} & : \quad _b[w] / (1 - _b[L.n]) \\
_{\text{n1}_2} & : \quad _b[k] / (1 - _b[L.n])
\end{align*}
\]

\[
\begin{array}{cccccc}
\text{n} & \text{Coeff.} & \text{Std. Err.} & \text{z} & \text{P>|z|} & \text{[95\% Conf. Interval]} \\
\hline
_{\text{n1}_1} & -1.494064 & .4484327 & -3.33 & 0.001 & -2.372976 & -0.6151519 \\
_{\text{n1}_2} & .8830199 & .1834742 & 4.81 & 0.000 & .523417 & 1.242623
\end{array}
\]
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.
- 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.


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


