Outline

- Estimating an investment equation using panel data.
  - Error-corrected accelerator model
  - Within and GMM-DIFF estimates
  - Results and conclusions
  - Implementation in TSP
Investment equations

Many empirical applications in panel data involve some kind of investment equation. Used to

- Evaluate the effects of tax or regulatory policy changes
- Test for the presence of “financial constraints”

Micro-economic estimates

- Some dissatisfaction with macro-economic results
- Rely on cross-sectional variation for identification, so basic price effects not identified. Variation in price (cost of capital) comes from
  1. Differing tax positions of different firms
  2. Differing cash flow (availability of internal funds) for different firms.
Modeling investment

Investment decisions involve

- **Adjustment costs**
  - Ad hoc dynamics added to neoclassical model
  - Derived from intertemporal optimization under uncertainty

- **Expectations about future profitability**
  - Past variables used as proxies for future, or to model future
  - Tobin’s q (market value=expected future profits)
  - Euler equations – marginal choice between two periods.

All modeling approaches imply the presence of lagged endogenous variables, which are problematic in panels that also have fixed effects.
Error-corrected accelerator model

Long run capital stock is proportional to firm output:

\[ k_{it} = \theta s_{it} + h_{it} \]

\[ k_{it} = \log \text{ of capital for firm } i \text{ end of year } t \]

\[ s_{it} = \log \text{ of output or sales for firm } i \text{ during } t \]

\[ h_{it} = \text{fcn of user cost of capital, prod. fcn.} \]

Specify dynamic adjustment between \( k \) and \( s \) using ADL(2,2):

\[ k_{it} = \alpha_i + \gamma_1 k_{i,t-1} + \gamma_2 k_{i,t-2} + \beta_0 s_{it} + \beta_1 s_{i,t-1} + \beta_2 s_{i,t-2} + \eta_{it} \]

\[ \Rightarrow \Delta k_{it} = \alpha_i + (\gamma_1 - 1)\Delta k_{i,t-1} + \beta_0 \Delta s_{it} + (\beta_0 + \beta_1) \Delta s_{i,t-1} \]

\[ + (\gamma_1 + \gamma_2 - 1)(k_{i,t-2} - s_{i,t-2}) + (\beta_0 + \beta_1 + \beta_2 + \gamma_1 + \gamma_2 - 1)s_{i,t-2} + \eta_{it} \]

Last two terms before disturbance provide t-tests for error-correcting behavior and long run constant returns. The first 3 terms describe short-run adjustment behavior.
Error-corrected accelerator

Replace growth in net capital by the investment rate $I/K$ and add cash flow (profits) terms:

$$\frac{I_{it}}{K_{i,t-1}} = \alpha_i + (\gamma_1 - 1)\frac{I_{i,t-1}}{K_{i,t-2}} + \beta_0 \Delta s_{it} + (\beta_0 + \beta_1) \Delta s_{i,t-1}$$

$$+ (\gamma_1 + \gamma_2 - 1)(k_{i,t-2} - s_{i,t-2}) + (\beta_0 + \beta_1 + \beta_2 + \gamma_1 + \gamma_2 - 1)s_{i,t-2}$$

$$+ \varphi_1 \frac{\pi_{it}}{K_{i,t-1}} + \varphi_2 \frac{\pi_{i,t-1}}{K_{i,t-2}} + \varphi_3 \frac{\pi_{i,t-2}}{K_{i,t-3}} + \eta_{it}$$

We expect the sum of the profits coefficients to be zero if they only capture transitory financial constraints.

Controlling for firm effects means estimating this equation in differenced form. The effects capture long run differences in the capital-output ratios.

Very similar to Euler equation derived from a dynamic program for intertemporal optimization by a profit-maximizing firm.
Estimation

Equation implies the usual linear panel data model with a lagged endogenous variable:

\[ y_{it} = x_{it} \beta + \eta_{it} = x_{it} \beta + \alpha_i + d_t + \epsilon_{it} \]

\( \alpha_i \) = differences in technology, depreciation, required rate of return
\( d_t \) = common macro-economic factors such as input prices

The time effects are ordinarily simply removed before estimation by demeaning the variables year by year.

Clearly we have \( E[\Delta \epsilon_{it} \mid x_{i1}, x_{i2}, \ldots, x_{iT}] \neq 0 \)
as well as \( E[\Delta \epsilon_{it} \mid x_{i1}, x_{i2}, \ldots, x_{it}] \neq 0 \)
So differenced OLS estimates are potentially very biased; Within estimates less so.
Preferred estimator is GMM, if we can find valid instruments.
Results

Table 5

- Focus on within estimates of error-corrected accelerator
- Slight decreasing returns to scale
- Longrun effect of a shock to sales on capital is about .6-.8
- Longrun effect of a cash flow shock on capital is about .6-.7 except in France in the second period.

Table 6

- Two instruments sets: lag 3 to 6, lag 2 to 6
- Specification tests:
  - Sargan accepts validity of instruments (barely)
  - LM tests for serially correlated errors prefer lag 3-6 inst.
  - No valid instruments for sales growth in France in period 2.
- Longrun effect of a shock to sales on capital still about .6-.7.
- Longrun effect of a cash flow shock on capital much weaker, esp. in US => there was simultaneity between investment and cash flow.
Conclusions

- When T=9 (as here), within estimates are close to first differenced and have smaller standard errors.
  - However, they are much more subject to simultaneity bias.
- Important to test for instrument validity to avoid being mislead by estimates that are essentially noise.
- GMM on first differences gives rather imprecise estimates.
- Long run response to output shock is around 0.6
- Long run response to profits shock is now around zero.
TSP example (1)

\begin{verbatim}
smpl 1 582 ; read (file="usbal8695.dat")
   logy186 logk186 logr186 logl186
   logy187 logk187 logr187 logl187
   ...
   logy194 logk194 logr194 logl194
   logy195 logk195 logr195 logl195
;
   dot 86 90 95 ;
   msd logy1. logk1. logr1. logl. ;
enddot ;
\end{verbatim}
TSP example (2)

```
dot 86-95;
  frml eq. logyl.-a.-bk*logkl.-bl*logl.;
enddot;

  frml deq87 eq87-eq86;
  frml deq88 eq88-eq87;
  ....
  frml deq95 eq95-eq94;
dot 87-95;
  eqsub deq. eq86-eq95;
enddot;

list deqs deq87-deq95;
list ivs c logkl86-logkl95 logl86-logl95;
length deqs ndeq;
length ivs ninst;
```
TSP example (3)

load (nrow=ninst,ncol=ndeq) mask1 ;

1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1
0 1 1 1 1 1 1 1 1
0 0 1 1 1 1 1 1 1
0 0 0 1 1 1 1 1 1
0 0 0 0 1 1 1 1 1

0 0 0 0 0 1 1 1 1
0 0 0 0 0 0 1 1 1
0 0 0 0 0 0 0 1 1
0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0

......

;
TSP example (4)

```
load (nrow=ninst,ncol=ndeq) mask2 ;
1 1 1 1 1 1 1 1 1
1 1 1 0 0 0 0 0 0
0 1 1 1 0 0 0 0 0
0 0 1 1 1 0 0 0 0
0 0 0 1 1 1 0 0 0
0 0 0 0 1 1 1 0 0
...

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TSP example (5)

```plaintext
param a87-a95 bk bl ;

title "GMM on FD with all level inst" ;
gmm (mask=mask1,inst=ivs,terse) deqs ;
lm2test ;

title "GMM on FD with 3 lags of level inst" ;
gmm (mask=mask2,inst=ivs,terse) deqs ;
lm2test ;
```