Regression with Time-Series Data:

Nonstationary Variables and Panel Data Models

15 Aug 2022, 10 am - 12.30pm

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Outline:

1. A brief history of econometrics development
2. Unit root
3. Panel Data Models

The Eminent Management University

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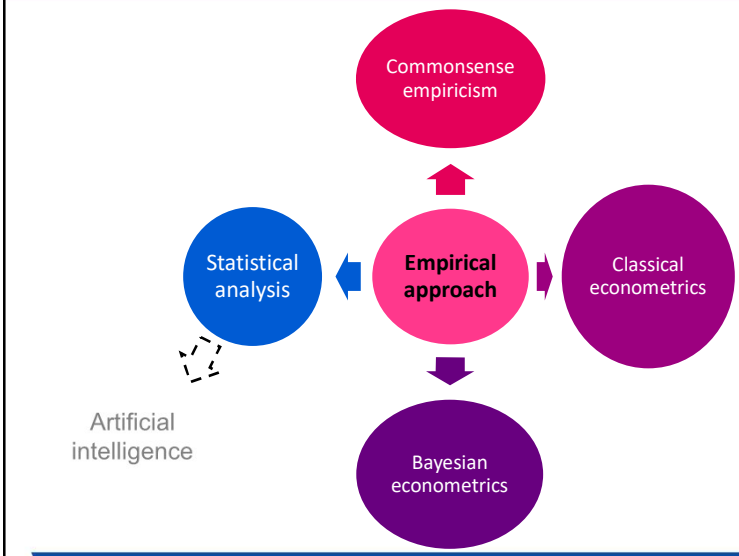
1. A brief history - Econometrics



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1. A brief history - Econometrics

- W.S. Jevon
- Sunspot theory

1875

Early 1900s

- 1911: Henry L. Moore – wage regression & correlation
- 1928: Wesley C. Mitchell – business cycle theory
- 1928: Henry Schultz – economic cycles, theory to determine DV and IVs

- Ragnar Frisch & Jan Tinbergen: founders of econometrics; macro-econometric models
- Alfred Cowles III: Cowles Commission for Research in Economics

1930-60s

Until 15 Aug 2022…

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2. Unit root

Unit

Root

Another number

X by itself a given number of times

one

Equal to the number

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2. Unit root

- A time series – dgp – as a series of monomial
- Each monomial corresponds to root
- Root =1: the time series has a Stochastic trend

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2. Unit root

A Time Series	So what?	Test
Stationary	Spurious problem	Augmented Dicker Fuller test (ADF)
Non-stationary	t-test distribution invalid	KPSS
		ADF-GLS test
		Phillips-Perron test
		etc

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2. Unit root

```
use http://www.stata-press.com/data/r12/lutkepohl2
tsset qtr
tsline consump
dfuller ln_consump , lags(2) trend regress
gen dlnconsump=ln_consump-L.ln_consump
tsline dlnconsump
dfuller dln_consump , lags(2) regress
```

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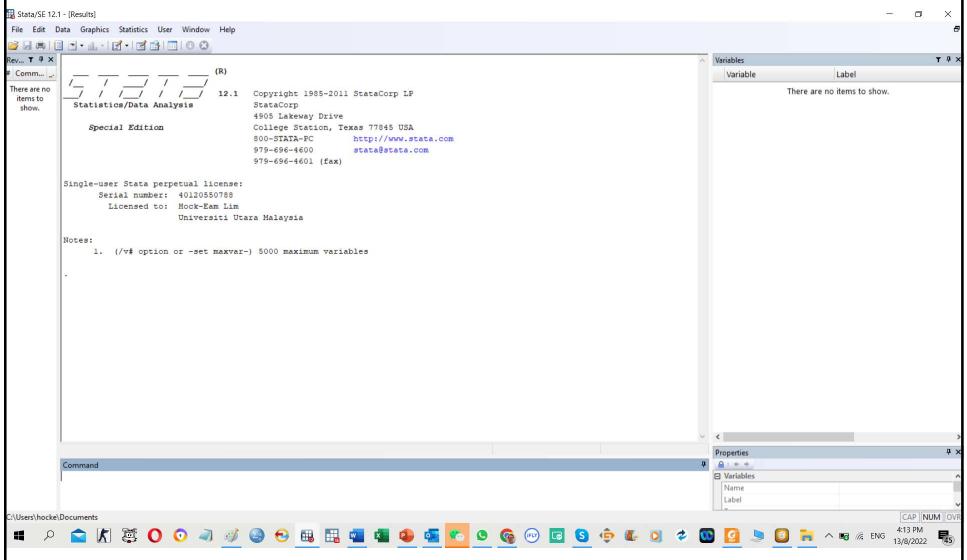

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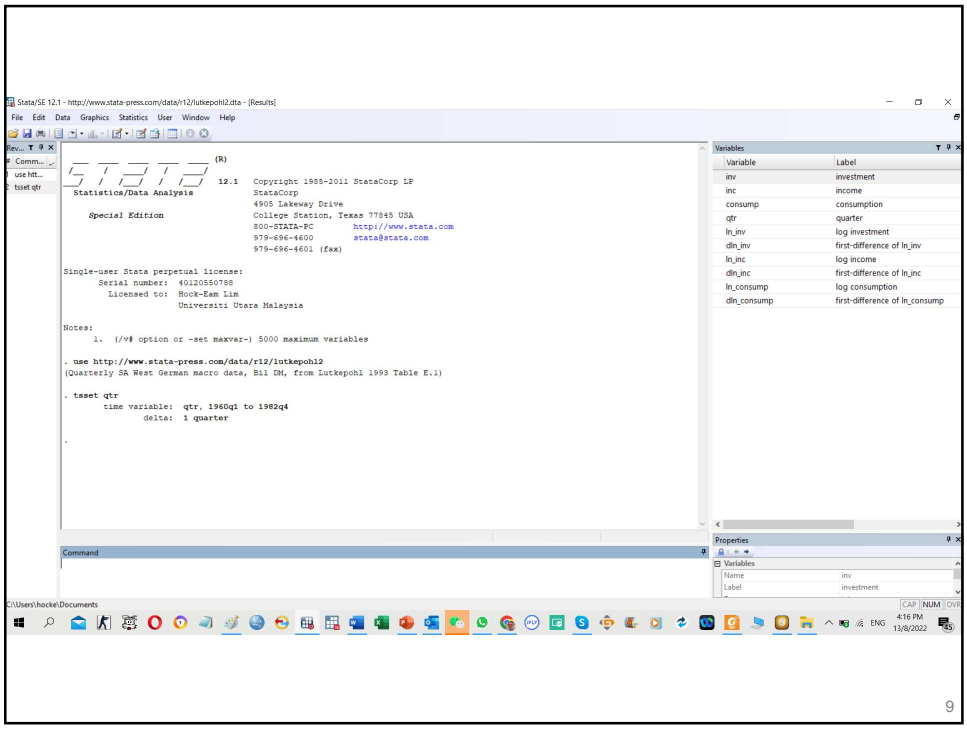
Stata/SE 12.1 - http://www.stata-press.com/data/r12/lutkepohl2.dta - [Results]
File Edit Data Graphics Statistics User Window Help
(R)
12.1
Statistics/Data Analysis
Special Edition
Copyright 1985-2011 StataCorp LP
StataCorp
4905 Lakeway Drive
College Station, Texas 77845 USA
800-STATA-PC http://www.stata.com
979-696-4600 stata@stata.com
979-696-4601 (fax)
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Universiti Utara Malaysia
Notes:
1. (/v# option or -set maxvar-) 5000 maximum variables
. use http://www.stata-press.com/data/r12/lutkepohl2
(Quarterly SA West German macro data, Bil DM, from Lutkepohl 1993 Table E.1)
. tsset qtr
time variable: qtr, 1960q1 to 1982q4
delta: 1 quarter
Variables
Variable Label
inv investment
inc income
consump consumption
qtr quarter
ln_inv log investment
dln_inv first-difference of ln_inv
ln_inc log income
dln_inc first-difference of ln_inc
ln_consump log consumption
dln_consump first-difference of ln_consump
Command
Properties
Variables
Name inv
Label investment
C:\Users\hocke\Documents
CAP NUM OVR
4:16 PM
13/8/2022

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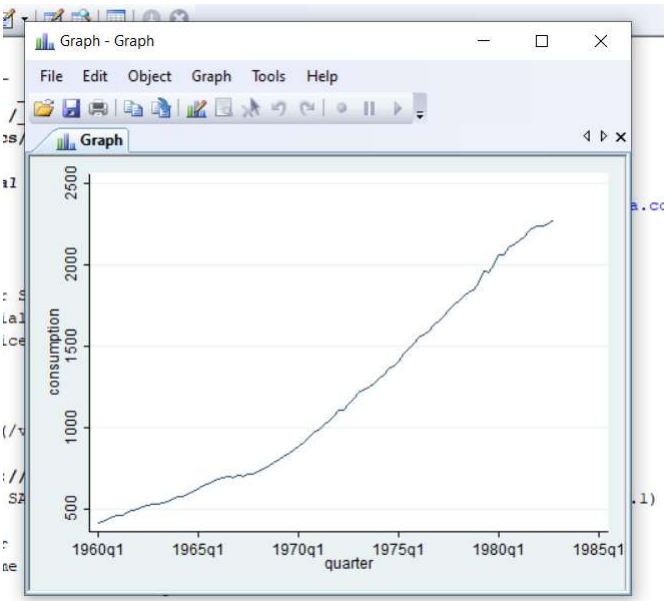
Graph - Graph
File Edit Object Graph Tools Help
Graph
consumption
500
1000
1500
2000
2500
1960q1
1965q1
1970q1
1975q1
1980q1
1985q1
quarter

10

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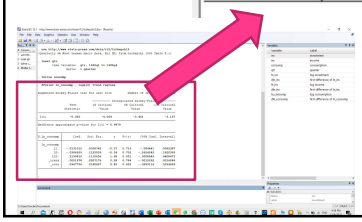
```
. dfuller ln_consump , lags(2) trend regress

Augmented Dickey-Fuller test for unit root         Number of obs   =        89

                                                 ---------- Interpolated Dickey-Fuller ----------
                     Test                 1% Critical         5% Critical         10% Critical
                  Statistic                   Value               Value               Value
------------------------------------------------------------------------------------------------
 Z(t)               -0.365                  -4.064              -3.461              -3.157
------------------------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9879

------------------------------------------------------------------------------
D.ln_consump |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
ln_consump   |
         L1. |  -.0131012   .0358742    -0.37   0.716    -.084441    .0582387
         LD. |  -.0386939   .1125059    -0.34   0.732    -.2624242   .1850363
        L2D. |   .2199812   .1110656     1.98   0.051    -.0008849   .4408473
      _trend |   .0001978   .0007176     0.28   0.784    -.0012292   .0016248
       _cons |   .0967756   .2140627     0.45   0.652    -.3289116   .5224628
------------------------------------------------------------------------------
```



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```
Augmented Dickey-Fuller test for unit root         Number of obs   =        88

                                                 ---------- Interpolated Dickey-Fuller ----------
                     Test                 1% Critical         5% Critical         10% Critical
                  Statistic                   Value               Value               Value
------------------------------------------------------------------------------------------------
 Z(t)               -3.127                  -3.527              -2.900              -2.585
------------------------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0246

------------------------------------------------------------------------------
D.           |
 dln_consump |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dln_consump  |
         L1. |  -.5330346   .1704469    -3.13   0.002    -.871987    -.1940822
         LD. |   -.574983   .1500217    -3.83   0.000    -.8733176   -.2766485
        L2D. |  -.3164129   .1045591    -3.03   0.003    -.5243401   -.1084857

       _cons |   .0095035   .0034108     2.79   0.007     .0027209    .0162862
------------------------------------------------------------------------------
```


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More power of test

dfgls ln_consump
dfgls dln_consump

kpss ln_consump
kpss dln_consump

Ho: no unit root
Complement and a test for fractional unit root

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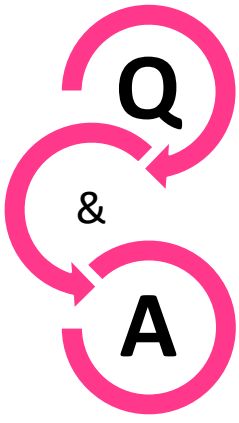

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Panel data unit root test:

Panel unit root test:
- Levin-Lin-Chu (LLC)
- Harris-Tsavalis (HT)
- Breitung (Beritung)
- Im-Pesaran-Shin (IPS)
- Fisher-type (Fisher)
- Hadri LM (Hadri)

Unbalanced Panel?
IPS and Fisher allowed.

Entity-specific unit root?
IPS and Fisher.

Entities (i) versus time periods (t)?
LCC (const/trend): t grows faster than i (macro)
LCC(noconst): t grows slower than i (micro)
HT (noconst): t fixed & i large (micro, no lags)
Breitung: large t & large/moderate i (higher power)
IPS: t & i fixed, t fixed & i large
IPS (with lags/trend): large t & large/moderate i
Fisher: t large & i large/finite
Hadri: large t and moderate/large i

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```
use http://www.stata-press.com/data/r12/pennxrate
encode country, gen(country1)
xtset country1 year
xtunitroot llc lnrxrate if g7, lags(aic 10)
xtunitroot llc lnrxrate if g7, lags(aic 10) demean
```

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```
. xtunitroot llc lnrxrate if g7, lags(aic 10)

Levin-Lin-Chu unit-root test for lnrxrate
---------------------------------------------
Ho: Panels contain unit roots               Number of panels  =      6
Ha: Panels are stationary                   Number of periods =     34

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1.00 lags average (chosen by AIC)
LR variance:     Bartlett kernel, 10.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t         -6.7538
 Adjusted t*          -4.0277        0.0000
------------------------------------------------------------------------------
```

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```
. xtunitroot llc lnrxrate if g7, lags(aic 10) demean

Levin-Lin-Chu unit-root test for lnrxrate
---------------------------------------------
Ho: Panels contain unit roots               Number of panels  =      6
Ha: Panels are stationary                   Number of periods =     34

AR parameter: Common                        Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1.50 lags average (chosen by AIC)
LR variance:     Bartlett kernel, 10.00 lags average (chosen by LLC)
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 Unadjusted t         -5.5473
 Adjusted t*          -2.0813        0.0187
------------------------------------------------------------------------------
```

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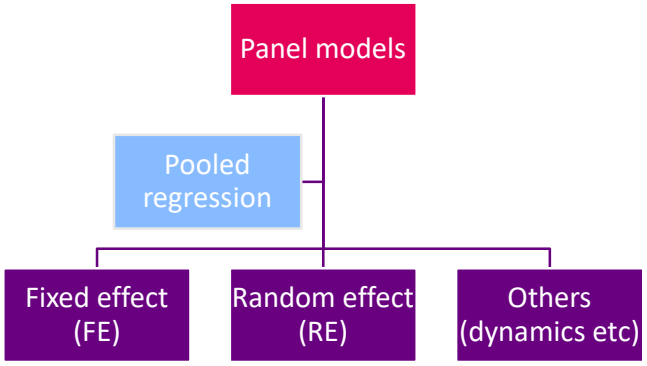
3. Panel Data Model

The similar entities (cross-sectional unit, panel unit, etc) is observed/followed over a period of time.



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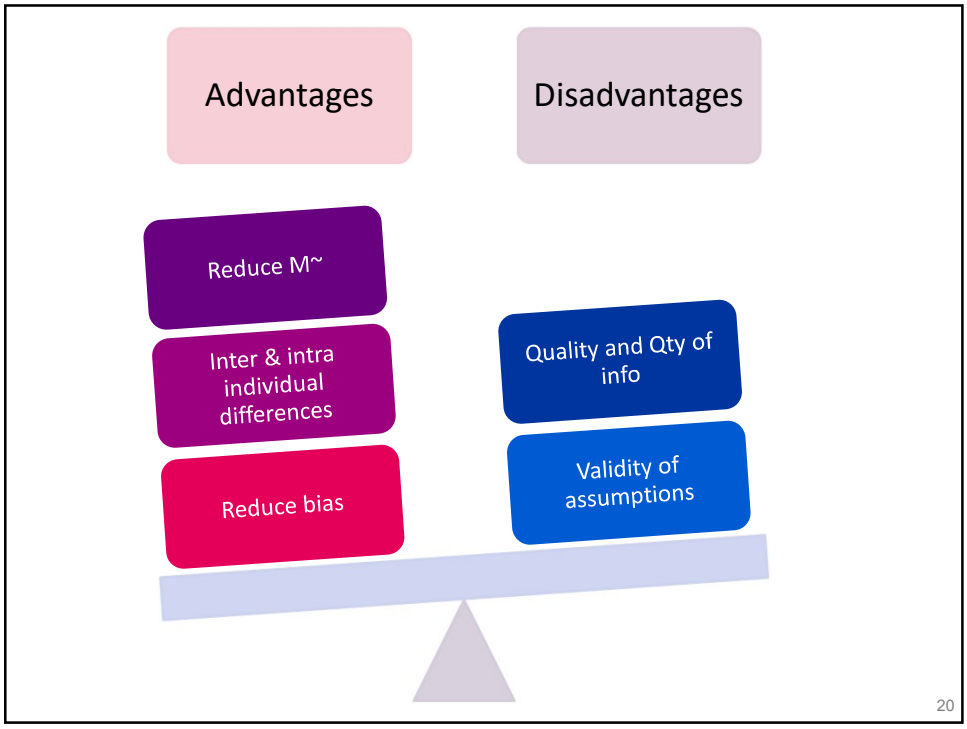

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A panel regression:

$$y_{it} = \beta_1 x_{it} + complicatederrorterm$$

t = 2000, 2001, …, T; i = 1, 2, …,n

β_1.

On average, one unit increase in *x* will lead to *B* units increase/decrease in *y*, in all cases.

Two different entities with one-unit difference in *x* (Between estimator)

A similar entity whose value of *x* increase by one unit over time (within estimator)

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$$y_{it} = \beta_1 x_{it} + a_i + u_{it}$$

FE

- Within estimator
- Eliminate ai by individual-demeaned the variables
- Useful if *cov(xij, ai)* is nonzero

BE

- Demeaned as well, but the mean over time (not individual)
- Useful when **Cov(Xbar, ai)** is nonzero

RE

- Use within and between variation – more efficient
- Weighted average of FE and BE esitmator
- Useful if **cov(xij, ai)** equal to zero

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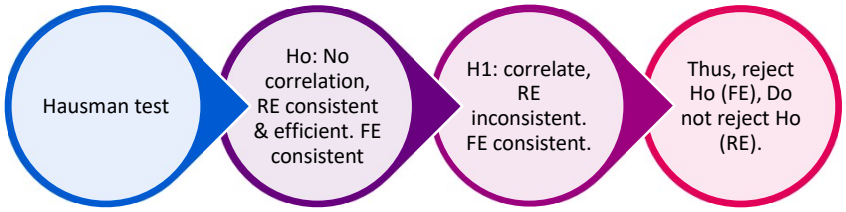
	Cov(x, a)=0	Cov(x, a) not =0
FE	consistent	Consistent (Clustered SE is needed)
RE	Consistent and efficient	Inconsistent



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```
use http://www.stata-press.com/data/r12/nlswork
xtset idcode year
gen age2=age*age
xtreg ln_w grade age age2 tenure, fe
xtreg ln_w grade age age2 tenure, re
```

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```
. xtreg ln_w grade age age2 tenure, fe
note: grade omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =     28099
Group variable: idcode                          Number of groups   =      4697

R-sq:  within  = 0.1375                         Obs per group: min =         1
       between = 0.2074                                        avg =       6.0
       overall = 0.1569                                        max =        15

                                                F(3,23399)         =   1243.00
corr(u_i, Xb)  = 0.1382                         Prob > F           =    0.0000

------------------------------------------------------------------------------
     ln_wage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       grade |          0  (omitted)
         age |   .0522751    .002783    18.78   0.000     .0468202     .05773
        age2 |  -.0006717   .0000461   -14.56   0.000    -.0007621    -.0005813
      tenure |    .021738    .000799    27.21   0.000      .020172     .023304
       _cons |   .6872007   .0405945    16.93   0.000     .6076329    .7667685
-------------+----------------------------------------------------------------
     sigma_u |  .38743287
     sigma_e |  .29674679
         rho |  .63025869   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(4696, 23399) =     7.98          Prob > F = 0.0000
```

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```
. xtreg ln_w grade age age2 tenure, re

Random-effects GLS regression                   Number of obs      =     28099
Group variable: idcode                          Number of groups   =      4697

R-sq:  within  = 0.1364                         Obs per group: min =         1
       between = 0.3898                                        avg =       6.0
       overall = 0.2936                                        max =        15

                                                Wald chi2(4)       =   6761.74
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
     ln_wage |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       grade |   .0768531   .0018705    41.09   0.000      .073187    .0805191
         age |    .051092   .0026671    19.16   0.000     .0458646    .0563195
        age2 |  -.0006821   .0000442   -15.44   0.000    -.0007687    -.0005956
      tenure |   .0258349   .0007312    35.33   0.000     .0244019     .027268
       _cons |  -.2617412   .0441182    -5.93   0.000    -.3482112    -.1752712
-------------+----------------------------------------------------------------
     sigma_u |  .28268257
     sigma_e |  .29674679
         rho |  .47574176   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

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xtreg ln_w grade age age2 tenure, re
estimates store RE
xtreg ln_w grade age age2 tenure, fe
estimates store FE
hausman FE RE

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```
. hausman FE RE
```

	Coefficients (b) FE	(B) RE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
age	.0522751	.051092	.0011831	.0007948
age2	-.0006717	-.0006821	.0000105	.0000133
tenure	.021738	.0258349	-.004097	.0003221

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 172.72
Prob>chi2 = 0.0000

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xtreg ln_w grade age age2 tenure, re
xttest0

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```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        ln_wage[idcode,t] = Xb + u[idcode] + e[idcode,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                 ln_wage |    .2283018       .4778094
                       e |    .0880587       .2967468
                       u |    .0799094       .2826826

        Test:   Var(u) = 0
                                  chibar2(01) = 18421.93
                              Prob > chibar2 =   0.0000
```

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Journey to the west…

GMM estimation method

Other panel data models

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Equilibrium

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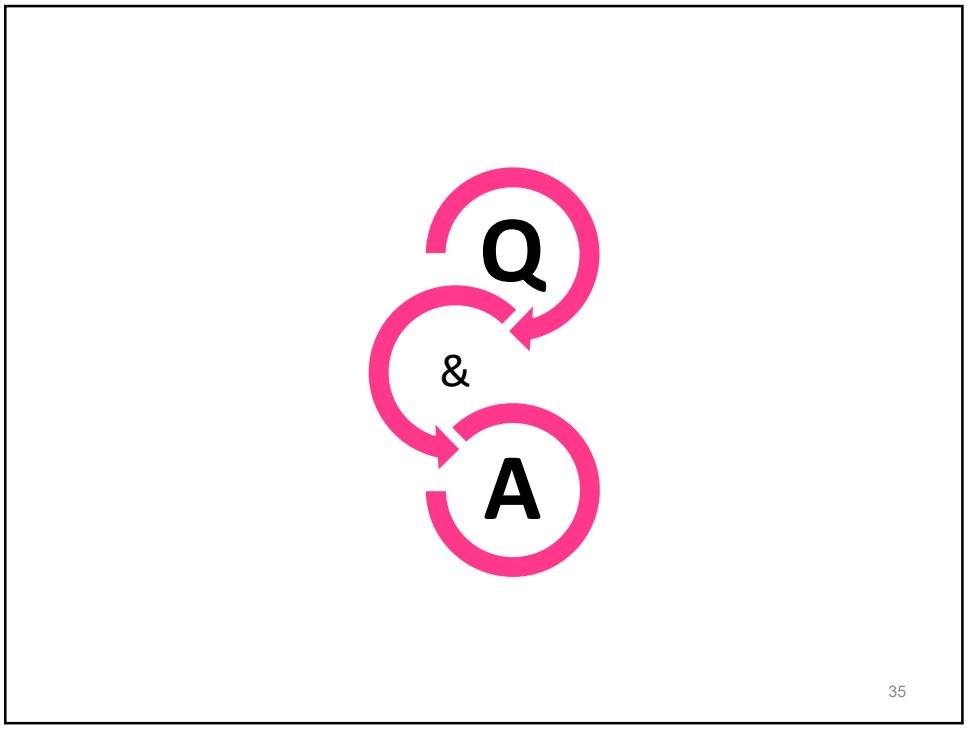

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