Panel Data

1) Cross - Sections x_i

2) Time Series x_t

3) Panel Data x_{it}

Advantages:

1) Bigger numbers

$n \cdot T$ → balanced

obj # time periods

2) Estimate dynamics

3) Fight endogeneity

$$y_{it} = \beta x_{it} + \mu_i + \varepsilon_{it}$$

μ_i - unobserved regional specifics

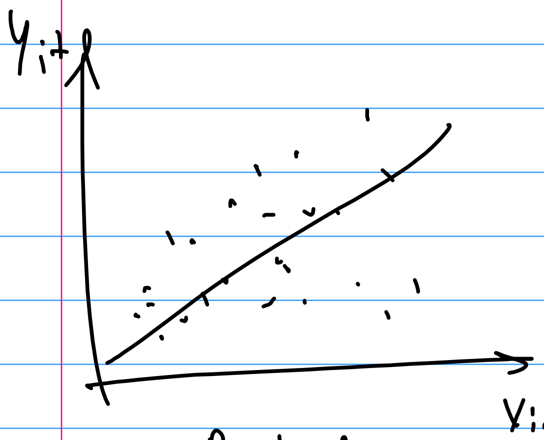
Pooled Regression

$$y_{it} = \beta_0 + \sum_{j=1}^{k} \beta_j X_{jit} + e_{it} \qquad [\mu_i = 0]$$

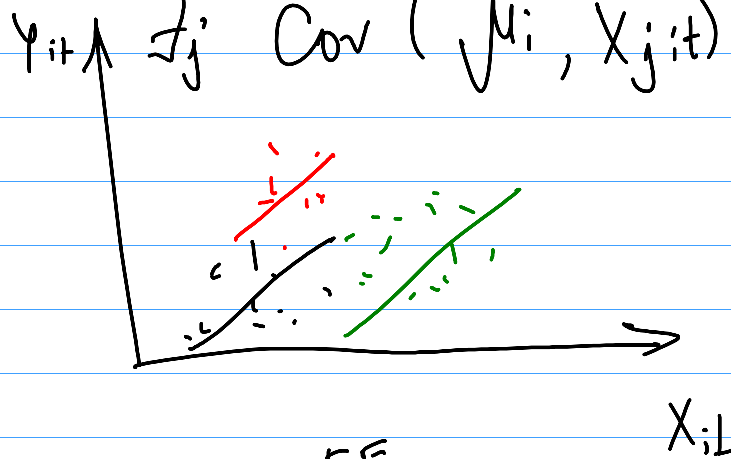
Fixed Effect

$$y_{it} = \beta_0 + \mu_i + \sum \beta_j X_{jit} + e_{it}$$

$$\exists j \quad Cov(\mu_i, X_{jit}) \neq 0$$



Pooled



FE

1) LSDV (Dummy Variable)
2) FD (First Difference)
3) Within - transform

① LSDV

$$y_{it} = \sum \alpha_i D_i + \sum \beta_j X_{it} + \varepsilon_{it}$$

D_i - dummy variable

Test: FE vs Pooled

F - test

$H_0: \alpha_2 = \dots = \alpha_n = 0$

② First Difference

$$y_{it} = \beta_0 + \mu_i + \sum \beta_j X_{jit} + \varepsilon_{it} \quad (*)$$

$(*)$ - Lag $(*)$

$$\underbrace{y_{it} - y_{it-1}}_{\Delta y_{it}} = \sum \beta_j \underbrace{(X_{jit} - X_{jit-1})}_{\Delta X_{it}} + \varepsilon_{it} - \varepsilon_{it-1}$$

③ Within - transformation

$$y_{it} - \bar{y}_i = \beta_0 + \mu_i + \sum \beta_j X_{jit} + \varepsilon_{it}$$
$$- \left(\beta_0 + \mu_i + \sum \beta_j \bar{X}_{ji} + \bar{\varepsilon}_i\right)$$

$$y_{it} - \bar{y}_i = \Sigma \beta_j (x_{jit} - \bar{x}_{ji}) + \varepsilon_{it} - \bar{\varepsilon}_i$$

Random Effects

$$y_{it} = \beta_0 + \Sigma \beta_j x_{jit} + \underbrace{\mu_i + \varepsilon_{it}}_{u_{it}}$$

Assume: $E(\mu_i) = 0$

$cov(\mu_i, x_{jit}) = 0$

Estimation using GLS

Test: RE vs Pooled

Breusch-Pagan (LM) test

H_0: $\sigma^2_{\mu_i} = 0 \quad \forall i$ (objects are homogenous)

FE vs RE

Type	Pooled	RE	FE
$\mu_i = 0$	BLUE	inefficient	inefficient
$cov(\mu_i, X_{it}) = 0$	inefficient	BLUE	inefficient
$cov(\mu_i, X_{it}) \neq 0$	biased + incons.	biased + incons.	BLUE

Hausman Test:

H_0: RE consistent

H_a: RE inconsistent => FE

$$(\hat{\beta}_{FE} - \hat{\beta}_{RE})^T (\hat{V}(\hat{\beta}_{FE}) - \hat{V}(\hat{\beta}_{RE}))(\hat{\beta}_{FE} - \hat{\beta}_{RE}) \sim \chi^2_k$$