14.452 Recitation 1

Panel Data, Democracy, Kaldor

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These slides build on work by past 14.452 TAs: Shinnosuke Kikuchi, Joel Flynn, Karthik Sastry, Ernest Liu, Ludwig Straub, . . .

Welcome/admin

- Welcome to 14.452!
  - great class for thinking rigorously about **big** questions
  - useful to see this material even if you're not into macro
  - lots of information/literature/models – try to keep the big picture in mind
- Recitation: Friday 2:30p-4p, E51-151 (exception: week of November 14)
- Office hours: Tuesday 10:30a-11:30a **and** 2:30p-4:00p, E52-548
- Email: tlensman@mit.edu
- Problem sets due at 2:30p on Friday

Recitations

- Please interrupt with any questions or comments
- Based on popular demand I will prioritize:
  1. practice problems related to the lectures/problem sets/exam
  2. review of lecture material
  3. open Q&A
  4. new paper discussion
- Slides posted online before recitations
- Let me know if this works for you – happy to adjust!

Plan for today

1. Intro to panel data
    - application to democracy and growth
2. Reviewing the Kaldor facts
    - closer look at factor shares
    - detour: elasticity of substitution

Panel Data, Democracy, and Growth

Setting

- $c \in \{1, \ldots, N\}$: cross-section (*countries*)
- $t \in \{1, \ldots, T\}$: time-series (*years*)
- y_{ct}: outcome (*per capita GDP*)
- D_{ct}: treatment (*democracy*)
- **Question**: what is the causal effect of D_{ct} on y_{ct}?
  - when could we identify such a causal effect, even though we aren't doing a proper laboratory experiment?

First pass model

$$y_{ct} = \delta_c + \gamma_t + \alpha D_{ct} + \varepsilon_{ct}$$

Why did we write this down?

- δ_c: country fixed effect
  - countries have *constant* characteristics over time
  - characteristics have *constant* effect on output
- γ_t: time fixed effect
  - aggregate shocks with *uniform* effects on the whole world
- αD_{ct}: coefficient of interest
  - democracy has the *same* impact on growth in all countries
- ε_{ct}: residual
  - everything we forgot about!
  - education, health, capital, weather, ...

Fixed effects and identification

- What happens if we just regress y_{ct} on D_{ct}?

$$y_{ct} = \alpha D_{ct} + u_{ct}$$

- What **story** undermines the regression?
  - "highly educated countries have high δ_c and more democracy. The correlation of democracy and output picks this up, even if democracy has a negative or zero effect on growth"

- Math version: $\text{Cov}[D_{ct}, u_{ct}] > 0$

$$\hat{\alpha} = \alpha + \frac{\hat{\text{Cov}}[D_{ct}, u_{ct}]}{\hat{\text{Var}}[D_{ct}]} > \alpha$$

Estimating fixed effects

- Let's estimate the regression with fixed effects
  - mechanics: include dummy variables for each country
- **Theorem (Frisch-Waugh)**: same as de-meaning each country:

$$(y_{ct} - \hat{\mathbb{E}}_t y_{ct}) = \alpha(D_{ct} - \hat{\mathbb{E}}_t D_{ct}) + (\gamma_t - \hat{\mathbb{E}}_t \gamma_t) + (\varepsilon_{ct} - \hat{\mathbb{E}}_t \varepsilon_{ct})$$

  - $\hat{\mathbb{E}}_t$ sample average w.r.t time t
  - does an increase of democracy *within* a country affect growth?
  - countries with $D_{ct} \neq D_{ct'}$ identify α
  - countries with D_{ct} fixed help to estimate γ_t
- Often called a "within estimator" because uses "within-country" variation

Strict exogeneity: the gold standard

- What assumption do we need for OLS to give unbiased estimates?
- Informally, need democracy at t to be uncorrelated with all past and future shocks to GDP
- This is implied by the usual assumption of *strict exogeneity*:

$$\mathbb{E}[\varepsilon_{ct}|\delta_c, (\gamma_s, D_{cs})_{s=1}^{T}] = 0, \quad \forall t \in \{1, \dots, T\}$$

- Note that this is stronger than the typical conditional mean independence assumption in cross-sectional regressions (need to estimate the c fixed effects)

First differences

- What if we estimated in first differences to remove the δ_c?

$$y_{ct} - y_{ct-1} = \alpha \left(D_{ct} - D_{ct-1}\right) + \gamma_t - \gamma_{t-1} + \varepsilon_{ct} - \varepsilon_{ct-1}$$

- This works, with the new identifying assumption

$$\mathbb{E}\left[\left(D_{ct} - D_{ct-1}\right)\left(\varepsilon_{ct} - \varepsilon_{ct-1}\right) | \gamma_t - \gamma_{t-1}\right] = 0.$$

- Hard to find examples where this would hold but strict exogeneity doesn't (what's so special about last year?)

Lags and identification

- What if democracy (and output) respond to previous shocks?
- Motivates including lagged y_{ct} or Δy_{ct} on the right-hand-side, e.g.

$$y_{ct} = \delta_c + \gamma_t + \alpha D_{ct} + \rho y_{ct-1} + \varepsilon_{ct}$$

- Does strict exogeneity still make sense? **No!**
  $\longrightarrow$ if $\rho > 0$, ε_{ct} must be correlated with regressors at $s \geq t+1$
- Informal identification condition:

$$\begin{aligned} \{D_{ct}, \text{ not predicted by lag GDP}\} &= \text{“Good variation in } D_{ct}\text{”} \\ &= \text{“As good as random”} \end{aligned}$$

- What exogeneity assumption makes sense in this case?
  PS1 Question – *check out “Democracy Does Cause Growth”*

Results

	log GDP	GDP growth	log GDP		
	(1)	(2)	(3)	(4)	(5)
Democracy	-10.112**	1.276***	0.973***	0.651***	0.794***
	(4.32)	(0.31)	(0.29)	(0.25)	(0.22)
log GDP (-1)			0.973***	1.266***	1.245***
			(0.01)	(0.04)	(0.04)
log GDP (-2)				-0.300***	-0.211***
				(0.04)	(0.05)
log GDP (-3)					-0.069***
					(0.02)
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	6934	6790	6790	6642	6490
R-squared	0.970	0.157	0.999	0.999	0.999

Table 1: Regression results. *Notes:* Standard errors clustered at the country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Nickell (1981) bias

- New econometric issues come up when including lagged outcome variables as regressors
- Nickell (1981): typical "within" estimator is biased for finite T
- This again follows from the failure of strict exogeneity:

$$\mathbb{E}\left[\left(y_{ct-1} - \hat{\mathbb{E}}_t y_{ct-1}\right)\left(\varepsilon_{ct} - \hat{\mathbb{E}}_t \varepsilon_{ct}\right)\right] \neq 0$$

- There are ways to deal with this bias, e.g. using GMM (Arellano & Bond 1991)
- Upshot: generally don't want to use OLS unless T is large

Kaldor Facts and Changing Factor Shares

What are the facts?

Kaldor, Nicholas (1957): "A Model of Economic Growth"

(i) Constant shares of national income to capital and labor

(ii) Constant growth of capital per worker

(iii) Constant growth of output per worker

(iv) Constant capital to output ratio

(v) Constant return on investment

(vi) There exist "acceptable" 2-5 percent variations in labor productivity growth across countries

We use these to define "balanced growth," but are they (still) true?

Factor shares with Cobb-Douglas production

- Suppose a Cobb-Douglas production function:

$$Y = F(K, L) = AK^{\alpha}L^{1-\alpha}$$

- Assuming markets are competitive, what share of output s_L is paid to workers?
  First find the wage:

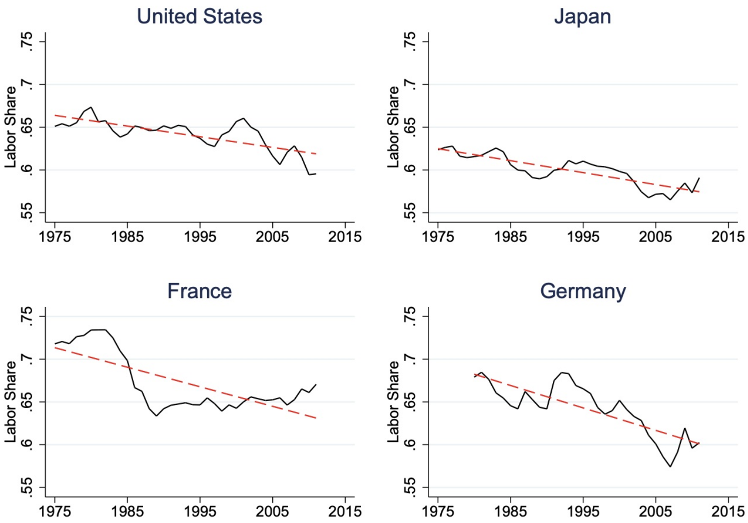
$$w = F_L(K, L) = (1-\alpha)AK^{\alpha}L^{-\alpha} = (1-\alpha)\frac{Y}{L}$$

- Rearrange:

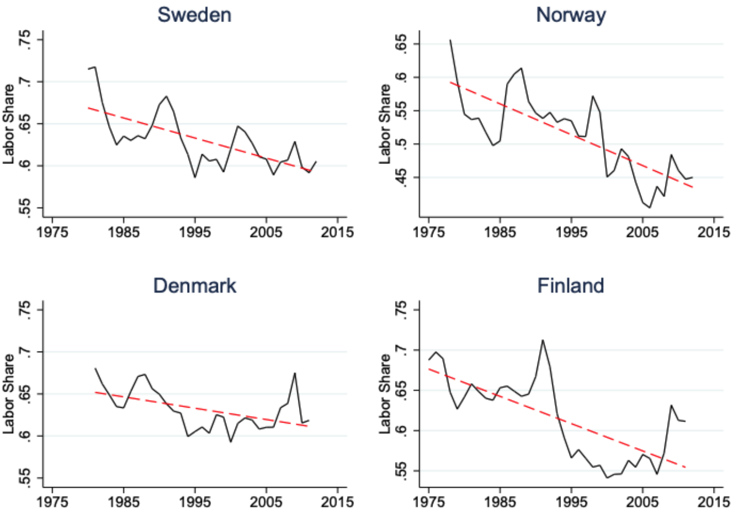
$$s_L = \frac{wL}{Y} = 1 - \alpha$$

- With Cobb-Douglas, factor shares are **constant** (indep. of prices/quantities)
- Is this true in the data?

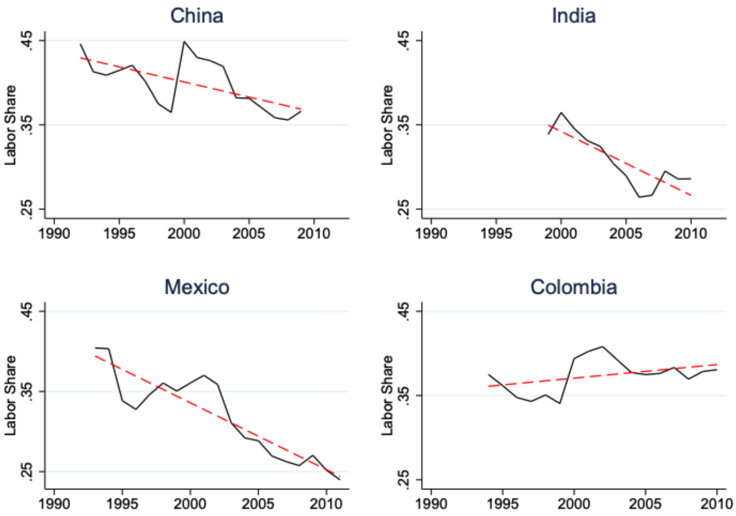
Advanced countries (Karabarbounis and Neiman 2014)



Other advanced countries (Karabarbounis and Neiman 2014)



Developing countries (Karabarbounis and Neiman 2014)



Many (potential) explanations

- Decrease in price of capital
- Superstar firms with low labor shares/ICT
- Automation
- China shock
- Labor market imperfections/regulations
- Accounting/mechanical reasons
  - intellectual property product capitalization
  - housing treatment
  - "profit share"

Grossman & Oberfield (2022): "The Elusive Explanation for the Declining Labor Share"

Falling capital price (Karabarbounis and Neiman 2014)

- Idea: fall in the price of capital R ($\approx$ productivity improvements in IT/computers) drives substitution away from labor and toward capital
- But even if K/Y increases (**quantity effect**), still have falling R (**price effect**)
  $\Rightarrow$ change in capital share $s_K = RK/Y$ is indeterminate
- *Didn't we just show that factor shares don't depend on prices anyway?*
- Yes, but only for Cobb-Douglas
  $\rightarrow$ too restrictive for thinking about the effects of prices on income shares

Beyond Cobb-Douglas: constant elasticity of substitution (CES)

- Arrow, Chenery, Minhas, & Solow (1961) introduce CES production:

$$F(K,L) = \left[\alpha (A_K K)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(A_L L)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

  - A_K, A_L factor-augmenting productivities
  - α share parameter
  - σ (constant) **elasticity of substitution**

- Looks messy, but learn to love it (at least in macro)

Why CES?

$$F\left(K,L\right)=\left[\alpha\left(A_KK\right)^{\frac{\sigma-1}{\sigma}}+\left(1-\alpha\right)\left(A_LL\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

1. Nice special cases

Perfect Complements as $\sigma\to 0$:

$$F\left(K,L\right)\to\min\left\{\frac{A_KK}{\alpha},\frac{A_LL}{1-\alpha}\right\}$$

Cobb-Douglas as $\sigma\to 1$:

$$F\left(K,L\right)\to\left(A_KK\right)^{\alpha}\left(A_LL\right)^{1-\alpha}$$

Perfect Substitutes as $\sigma\to\infty$:

$$F\left(K,L\right)=\alpha A_KK+\left(1-\alpha\right)A_LL$$

Why CES?

$$F(K,L) = \left[\alpha (A_K K)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(A_L L)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

2. Unit cost function (**price index**) is also CES with elasticity $1/\sigma$:

$$P = c(R,w) = \left[\alpha^{\sigma}\left(\frac{R}{A_K}\right)^{1-\sigma} + (1-\alpha)^{\sigma}\left(\frac{w}{A_L}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

Why CES?

$$F(K,L) = \left[\alpha\left(A_K K\right)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)\left(A_L L\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

3. Convenient factor shares that *depend on prices!*

$$\frac{s_K}{1-s_K} = \frac{\frac{RK}{Y}}{\frac{wL}{Y}} = \left(\frac{\alpha}{1-\alpha}\right)^{\sigma}\left(\frac{R/A_K}{w/A_L}\right)^{1-\sigma}$$

- capital share decreasing in relative capital price $\iff \sigma > 1$
- price effect dominates for $\sigma < 1$, quantity effect dominates for $\sigma > 1$

Back to falling capital prices

- With more flexible (CES) substitution, can a decline in the relative price of capital R/w explain the decline in the labor share s_L?

  $\longrightarrow$ only if $\sigma > 1$ (capital and labor are substitutes)

- Oberfield & Raval (2021): "Micro Data and Macro Technology"

  $\longrightarrow$ σ around $0.5 - 0.7$ in US manufacturing sector

- Falling capital price probably isn't the explanation!

One last thing...

- But what is σ? More generally, what is an elasticity of substitution (EoS)?
- For **homothetic** production function $F(K, L)$, EoS measures the curvature of an isoquant:

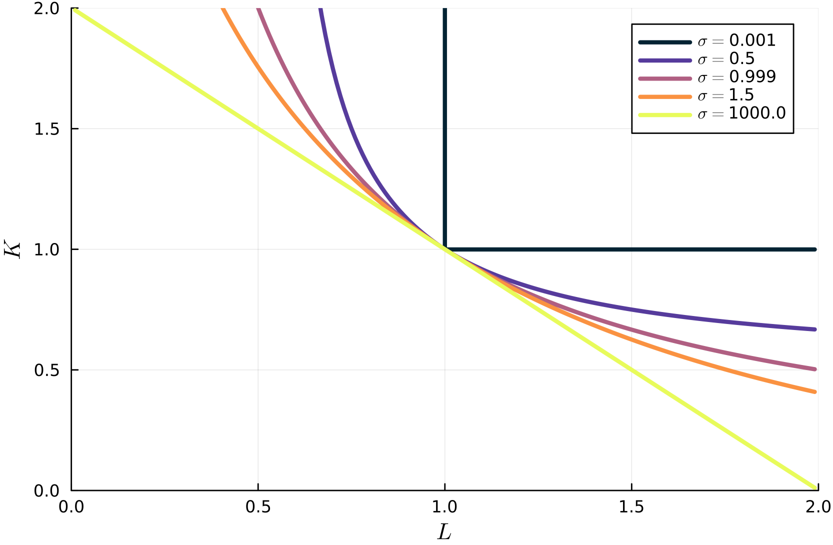
$$\frac{1}{EoS\left(\frac{K}{L}\right)} = -\frac{\partial \log\left(\frac{F_K}{F_L}\right)}{\partial \log\left(\frac{K}{L}\right)}$$

  - higher EoS $\Rightarrow$ "flatter" isoquant $\Rightarrow$ K, L "more substitutable"
- Equivalently, EoS measures change in cost-minimizing input ratio w.r.t. price ratio:

$$EoS\left(\frac{r}{w}\right) = -\frac{\partial \log\left(\frac{K}{L}\right)}{\partial \log\left(\frac{r}{w}\right)}$$

- CES F is the **unique** F with EoS independent of quantities (or prices)
- Lots of other concepts of EoS when production function has ≥ 3 inputs
  Allen-Uzawa, Morishima, ...

CES in a figure



Questions?