Skill Supply and the Organization of Production
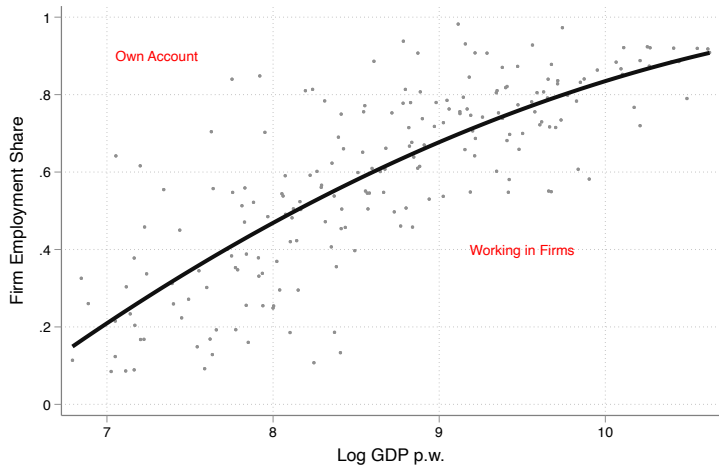
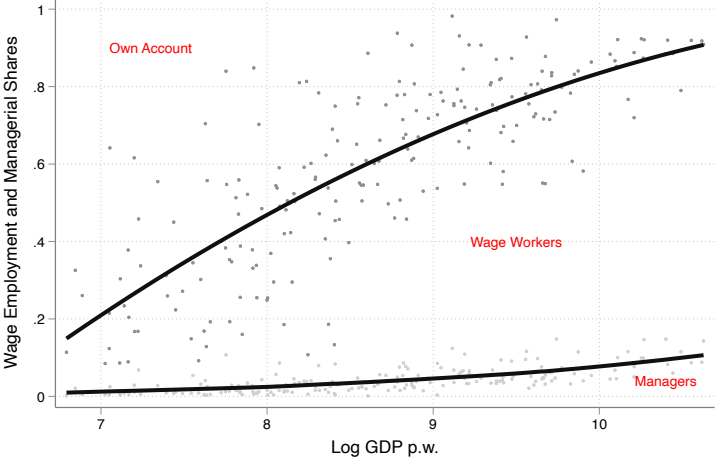Tommaso Porzio[1]   Federico Rossi[2]
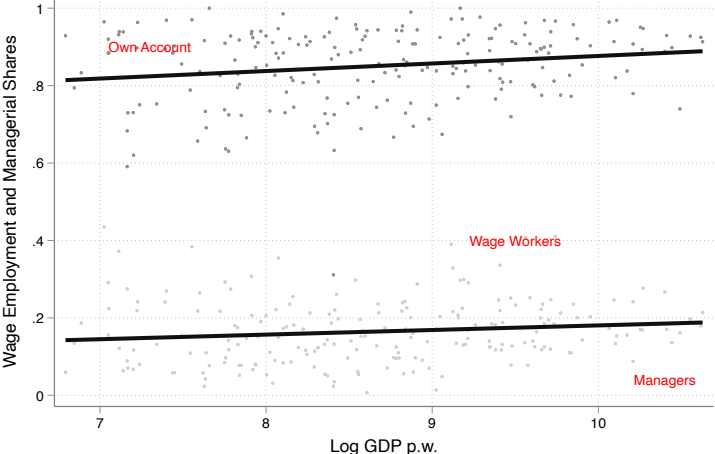
[1]Columbia

[2]Warwick

August 2023

Occupational Structure and Development

Occupational Structure and Development

Occupational Structure - Secondary Educated

This Project

1. **Occupational accounting**
   - Schooling accounts for most variation in organizational structure across countries and over time
   - New cohorts drive most of changes over time

2. **Evidence on link between schooling and occupational choice**
   - Exploit variation across cohorts
   - ↑ schooling → ↓ own account work, ↑ wage employment

3. **Occupational choice model**
   - Structural counterpart of occupational accounting
   - Implications for development accounting

Related Literature

Outline

Data and Definitions

Data

- Micro data from labor force surveys/censuses (IPUMS International)

- 206 cross-sections from 70 countries

- Cover large part of the income distribution (from Mali to Canada)

Occupational Classification

(1) Managers

- ▸ Wage employed in managerial occupation (*Legislators, senior officials and managers*)
- ▸ Self-employed with employees reporting managerial occupation (small share)
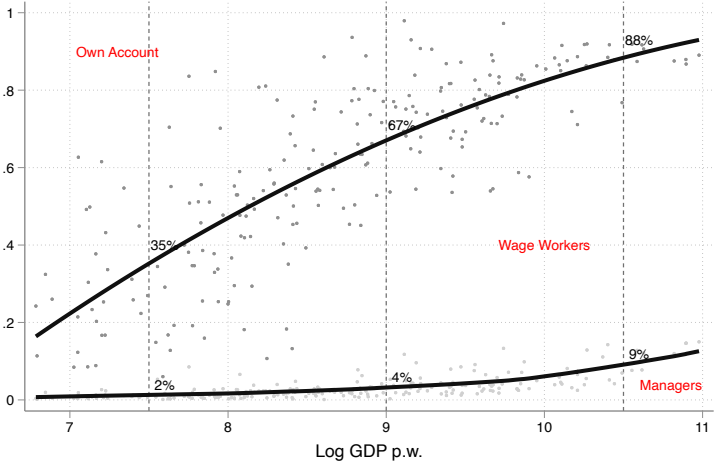
(2) Wage Workers

- ▸ Wage employed in non-managerial occupation

(3) Own Account Workers

- ▸ Self-employed without any employee

- ▸ $(1) + (2) \approx$ Wage employed

- ▸ Exclude employers without managerial role (small share)

Occupational Structure across Countries

Occupational Accounting

Does schooling account for cross-country differences in occupational shares?

Occupational Accounting

- $\sigma_{e,c}$ = share of labor force in country c with education $e \in \{$No Primary, Primary, Secondary, Tertiary$\}$
- $S_{e,c}^j$ = share of edu group e employed in occupation j
- Overall employment share in j:

$$S_c^j = \sum_e \sigma_{e,c} S_{e,c}^j$$

- Accounting counterfactual with edu shares of country R:

$$S_c^{j,\text{ACC}} = \sum_e \sigma_{e,R} S_{e,c}^j$$

- Accounting countribution of education differences

$$\text{Acc Share}_c^j = \frac{\log S_c^{j,\text{ACC}} - \log S_c^j}{\log S_R^j - \log S_c^j}$$

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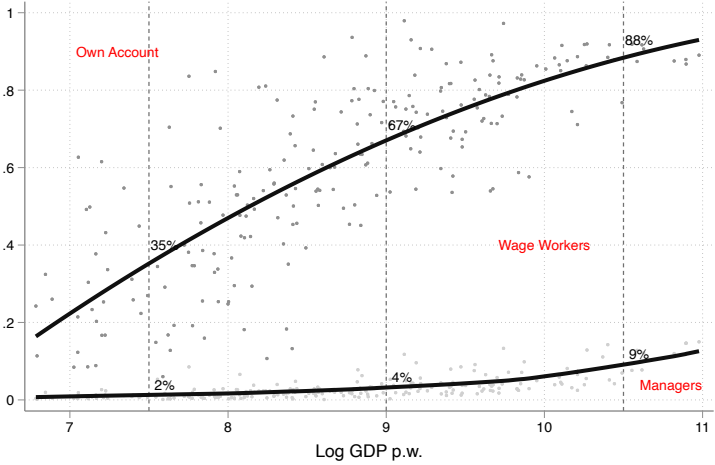- Accounting counterfactual with edu shares of country R:

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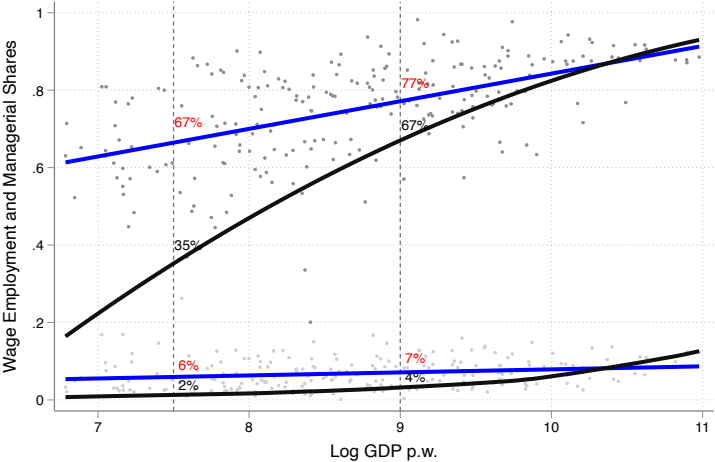$$\text{Acc Share}_c^j = \frac{\log S_c^{j,\text{ACC}} - \log S_c^j}{\log S_R^j - \log S_c^j}$$
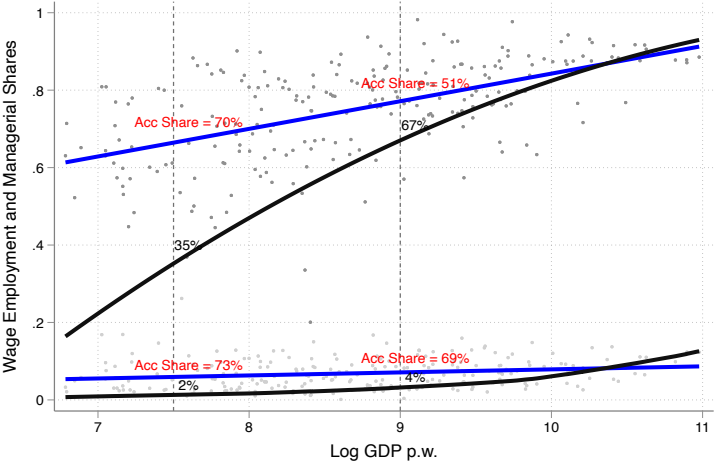
Occupational Accounting

Occupational Accounting

Edu Profiles

Occupational Accounting

Edu Profiles

Other Empirical Results

- Even larger role of education for changes over time `Show`

- Large contribution of new cohorts `Show`

- Evidence of causal link: schooling $\rightarrow$ occupational choice
  - $\rightarrow$ Across cohorts, $\uparrow$ schooling, $\rightarrow$ $\downarrow$ own account, $\uparrow$ wage employment `Show`
  - $\rightarrow$ School construction program in Indonesia: $\uparrow$ schooling, $\downarrow$ own account, $\uparrow$ wage employment `Show`

Evidence from Indonesia

Evidence from INPRES

- INPRES → primary school construction program in Indonesia (1974-1978)

- As in Duflo (2001), exploit variation in
    - Intensity of program by district
    - Exposure across cohorts (only young enough fully treated)

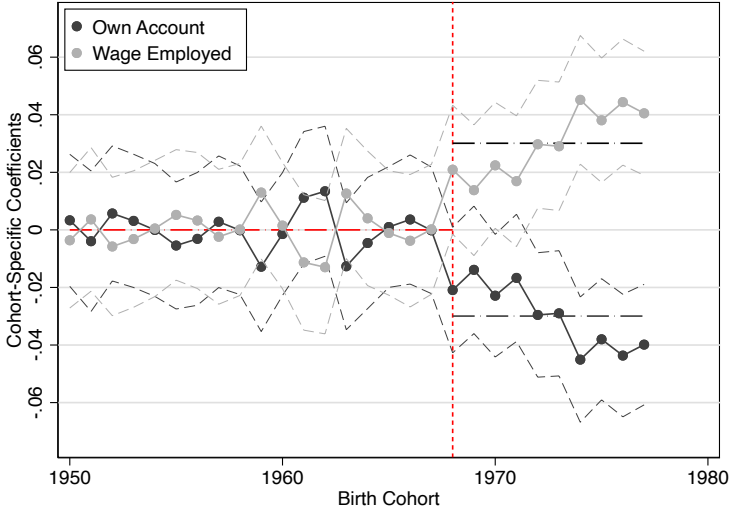- We estimate for individual i in cohort c and district d

$$y_{i,c,d} = \alpha_c + \eta_d + \sum_{k=1950}^{1977} \delta_k T_d \mathbb{1}\left(k = c\right) + \varepsilon_{i,c,d}$$

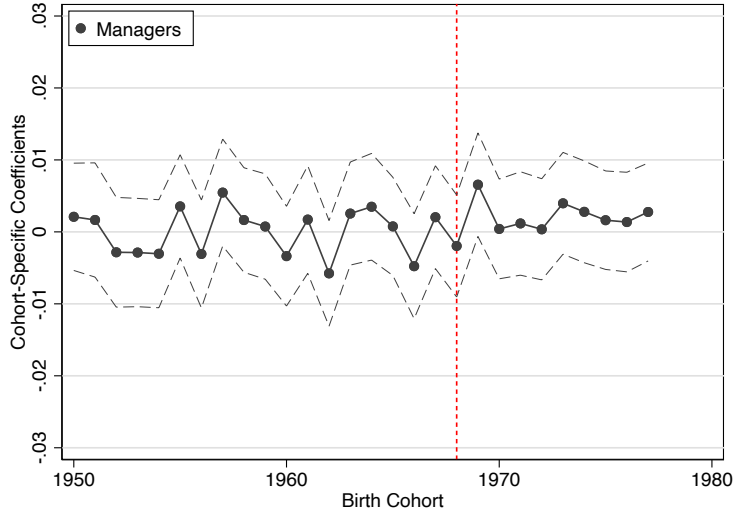where T_d = number of built schools per pupil in district d

Indonesia - Schooling Results
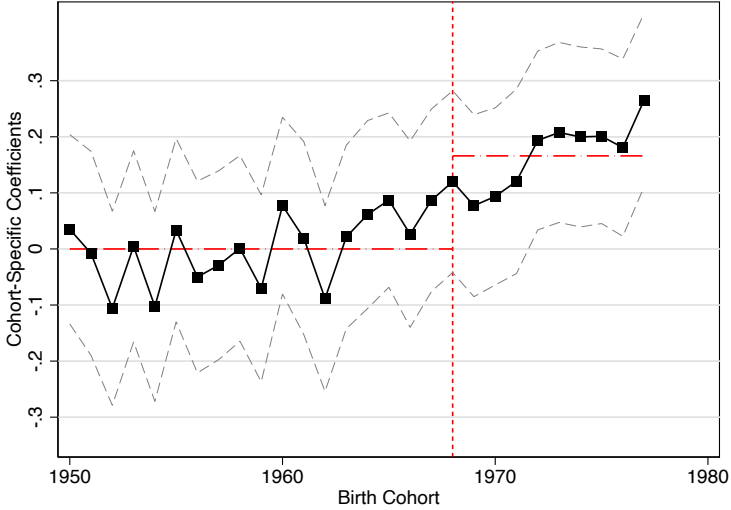
Indonesia - Employment Results

More Results

Indonesia - Employment Results

Model

Setup

- Lucas (1978) with skill heterogeneity by education

- Mass σ_e of workers with education e

- Human capital $h(e, x) = h_e x$

  - $h_e \rightarrow$ average skill by education

  - $x \rightarrow$ idyosincratic ability, $x \sim$ Pareto with mean 1 and shape α

- Occupational choice

  - Own account: produce Z

  - Wage worker: supply $h(e, x)$ efficiency units

  - Manager: hire $l(h(e, x))$ efficiency units and get profits from producing with

    $$y = Ah(e, x)l\left[h\left(e, x\right)\right]^{\gamma}$$

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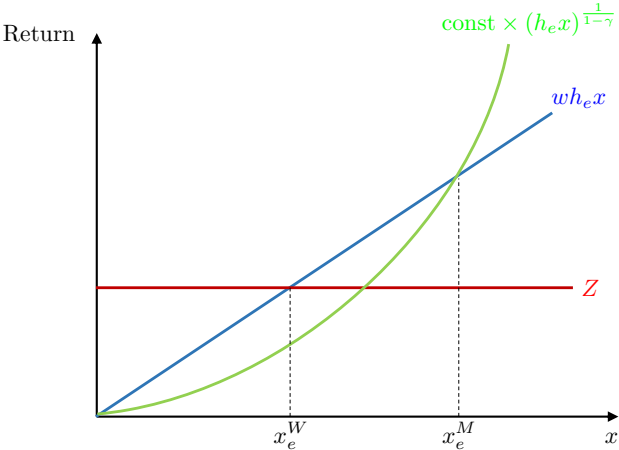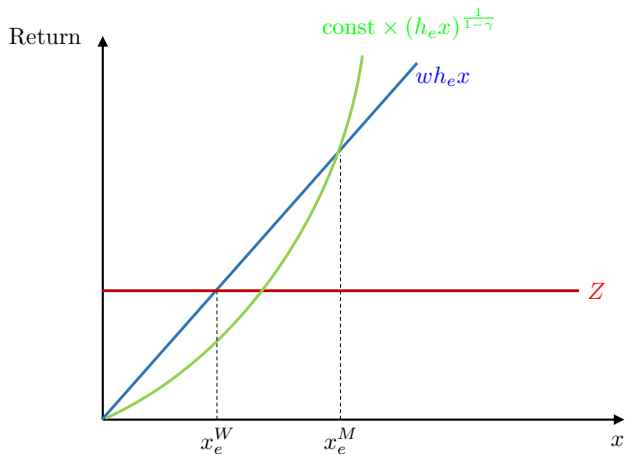
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Occupational Choice

Occupational Choice - Higher h_e

The figure shows "Return" on the vertical axis and x on the horizontal axis. A green curve labeled $\text{const} \times (h_e x)^{\frac{1}{1-\gamma}}$, a blue line labeled $w h_e x$, and a red horizontal line labeled Z. Vertical dashed lines mark x_e^W and x_e^M on the horizontal axis.

Occupational Shares by Education

$$S_e^{\text{Managers}} = g_M \left(\underset{+}{A/Z} \right) h_e^{\alpha}$$

$$S_e^{\text{Wage Workers}} = g_W \left(\underset{+}{A/Z} \right) h_e^{\alpha}$$

$$S_e^{\text{Own Account}} = 1 - \left[g_M \left(\underset{+}{A/Z} \right) + g_W \left(\underset{+}{A/Z} \right) \right] h_e^{\alpha}$$

- $\uparrow A/Z \rightarrow \uparrow$ wage employment for all edu groups

- Differences in $h_e \rightarrow$ differences in wage employment between edu groups

Aggregate Occupational Shares

$$S^{\text{Managers}} = g_M \left(\underset{+}{A/Z} \right) \sum_e \sigma_e h_e^\alpha$$

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▸ Occupational Accounting $\rightarrow$ change distribution of σ_e keeping A/Z fixed

Proposition

Accounting = equilibrium effect of changes in skill (education) supply

Equilibrium Wage

Aggregate Occupational Shares

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Equilibrium Wage

Breaking the Equivalence: Imperfect Substitutability

Imperfect Substitutability

- Suppose own-account produce y_T and firms produce y_M

$$U(c_T, c_M) = \left(c_T^{\frac{\eta}{\eta-1}} + c_M^{\frac{\eta}{\eta-1}} \right)^{\frac{\eta-1}{\eta}}$$

- Occupational shares ($p_M = 1$)

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If $\eta < \infty$, accounting overstates changes in occupational shares

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Proposition

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An Exploratory Calibration

- Calibrate model for low-income countries

- Pick A/Z, α, γ, h_e to match
    - Wage employment shares by education
    - Worker per manager ratio
    - Managerial wage premium

- Counterfactual $\rightarrow$ high-income edu shares

Results - Low Income Countries

	Elasticity of Substitution (η)				
	1	2	4	8	∞
Wage Employed (Data)	0.37	0.37	0.37	0.37	0.37
Wage Employed (Counterfactual)	0.37	0.41	0.46	0.51	0.66
Accounting Share	-0.01	0.11	0.24	0.36	0.67

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▸ Benchmark → education explains 2/3 of differences in wage employment

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- Lagakos et al (2023) $\rightarrow$ correlation between relative price of 8 traditional goods (haircuts, shoe repairs..) and GDP suggests $\eta \approx 4$
- $\rightarrow$ education explains 1/4 of differences in wage employment

Implications for Development Accounting

Wage Gaps Understate Human Capital Gaps

- π_e = average earnings of *wage employed* in edu group e

Proposition

$\pi_e = \pi$ for all e. Details

- Differential selection on ability $\to$ no education premium among wage employed

- General point $\to$ wage gaps among wage employed understate human capital gaps

- Development accounting understates role of education

$\to$ In progress: harmonization of data on self-employment income/consumption to quantify this Cross-Sector Returns

Conclusions

Conclusions

1. Large accounting role of education for differences in organization of production

2. Schooling gives comparative advantage for working in firms

3. Simple model where accounting maps into structural effects

4. Development accounting understates role of education

$\rightarrow$ Next steps: more data to discipline (3) and (4)

Accounting for Education - Over Time

- Estimate for country c, education group e, year t and occupation j

$$S_{c,e,t}^{j} = \alpha + \sum_{k=1}^{2} \beta_k \log y_{i,t}^{k} + \gamma_c + \delta_{c,e} + \varepsilon_{c,i,t}$$

- Display predicted values with and without country $\times$ education dummies

Accounting for Cohort Effects

▸ Estimate for cohort c, in country i, year t and occupation j

$$S^j_{c,i,t} = \alpha + \sum_{k=1}^{2} \beta_k \log y^k_{i,t} + \gamma_i + \delta_{i,c} + \zeta' X_{c,i,t} + \varepsilon_{c,i,t}$$

where $X_{c,i,t}$ includes controls for age (restricted to be flat around 50)

▸ Display predicted values with and without cohort effects

Occupational Structure Within Sectors
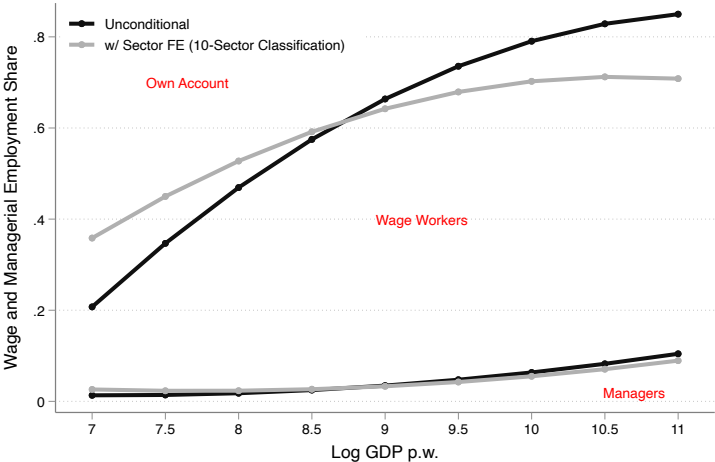
Agriculture
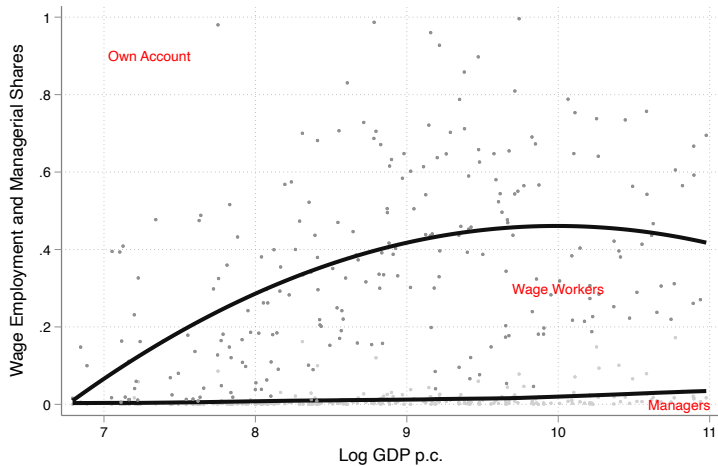
Manufacturing
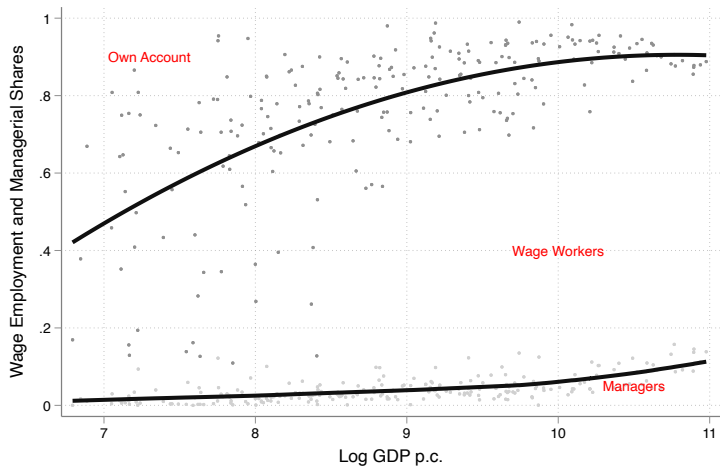
Services
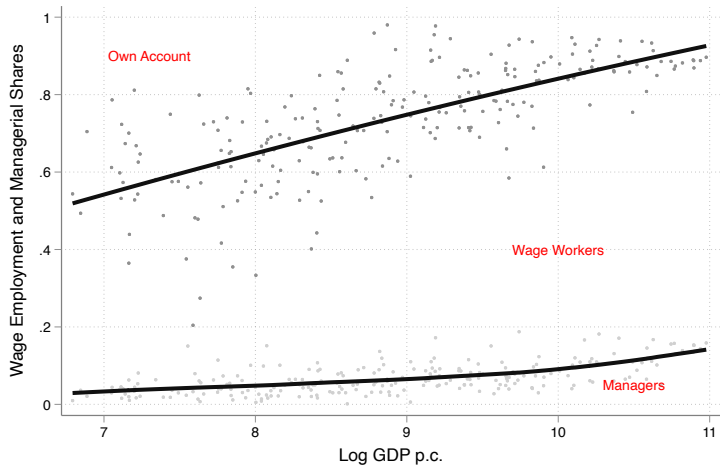
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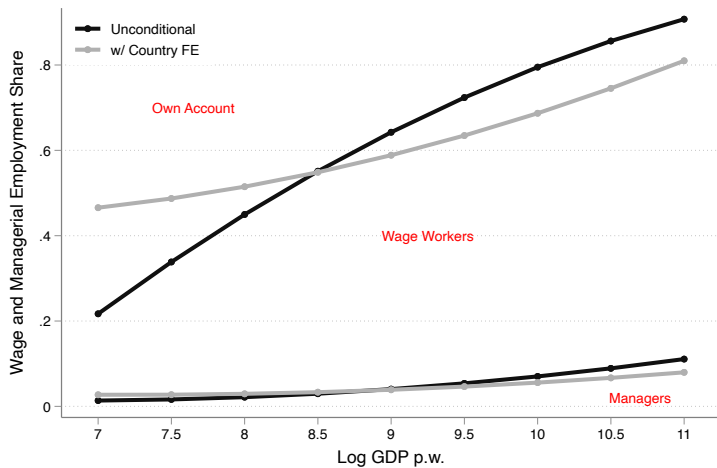
Occupational Choice ($Z = 0$)
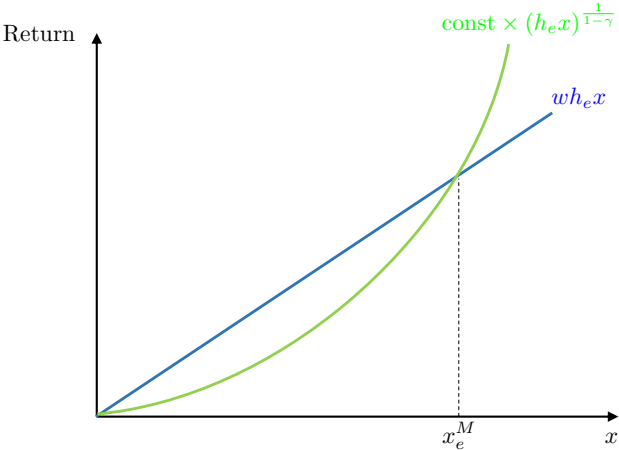
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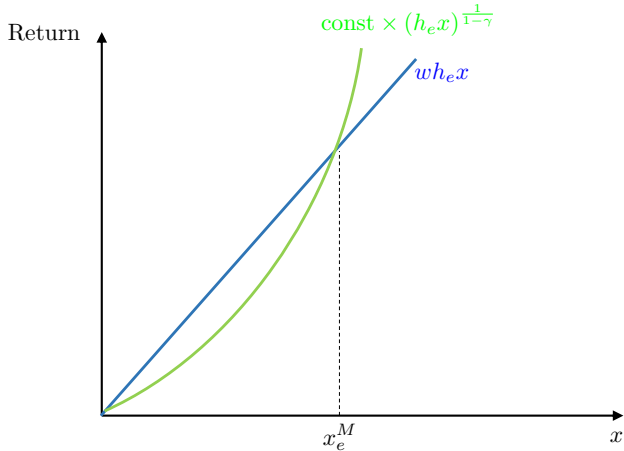
Occupational Shares in Partial Equilibrium

▸ Aggregate occupational shares

$$S^{\text{Managers}} = g_M \left(\underline{w} \right) \sum_e \sigma_e h_e^\alpha$$

$$S^{\text{Wage Workers}} = 1 - g_M \left(\underline{w} \right) \sum_e \sigma_e h_e^\alpha$$

▸ In equilibrium cannot have both $S^{\text{Managers}} \uparrow$ and $S^{\text{Wage Workers}} \downarrow$

▸ w adjusts $\rightarrow$ Structural effect $\neq$ Occupational accounting

Labor Market Equilibrium ($Z = 0$)
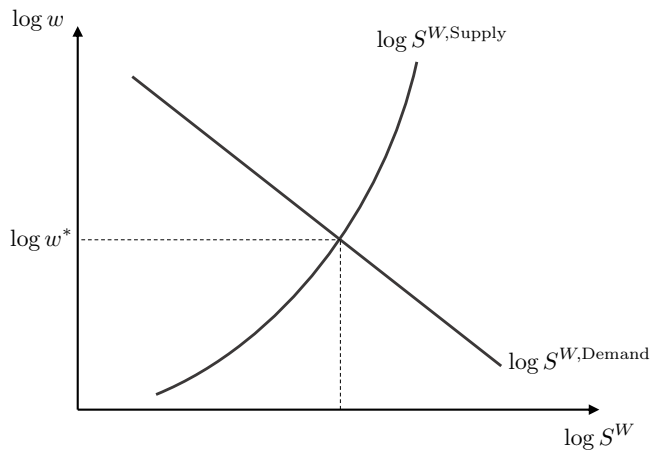
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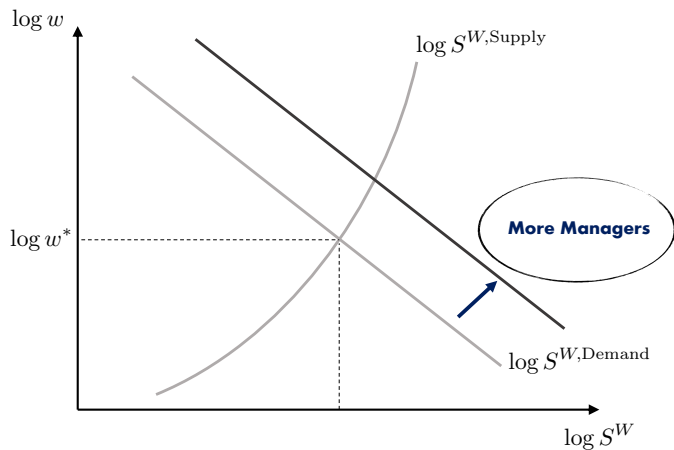
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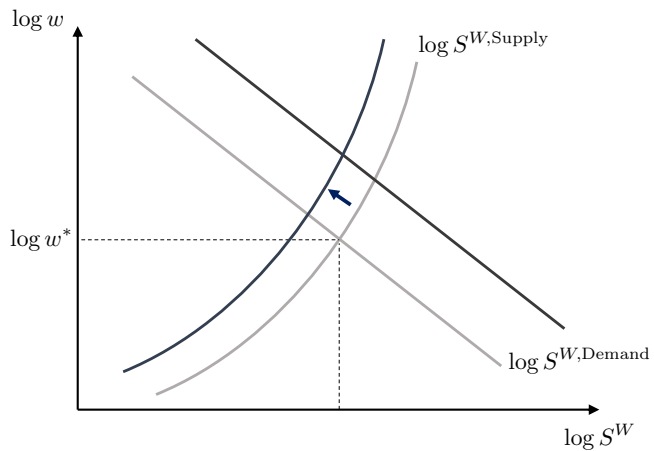
Occupational Accounting < Structural Effect

- Compare accounting counterfactual (ignoring own-account)

$$S_c^{j,\text{ACC}} = \sum_e \sigma_{e,R} S_{e,c}^j$$

with model-based counterfactual $S_c^{j,\text{MODEL}}$

Proposition

*Suppose $\sum_e \sigma_{e,R} h_{e,c} > \sigma_{e,c} h_{e,c}$. Then,*

$$S_c^{Manager,ACC} > S_c^{Manager,MODEL}$$
$$S_c^{Wage\ Worker,ACC} < S_c^{WageWorker,MODEL}$$

- No own account → no increase in labor supply

Back

Fixed Managerial Pool

- Mass M of managers, each with human capital normalised to 1 (isomorphic to A)

- Human capital endowments as in baseline case

- Occupational choice
  - Own account → produce Z
  - Wage worker → supply $h(e, x)$ efficiency units

Occupational Choice (Fixed Managerial Pool)
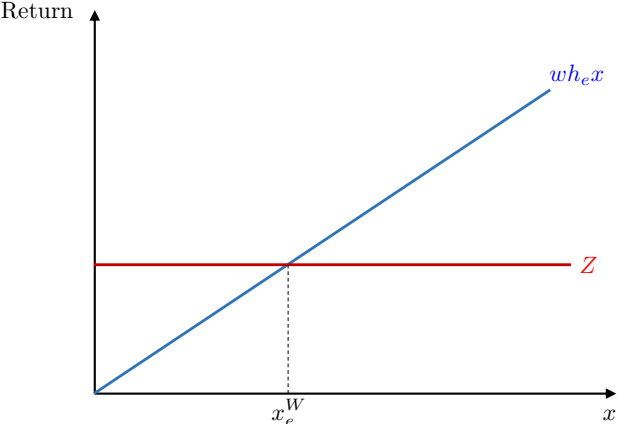
Occupational Choice (Fixed Managerial Pool)
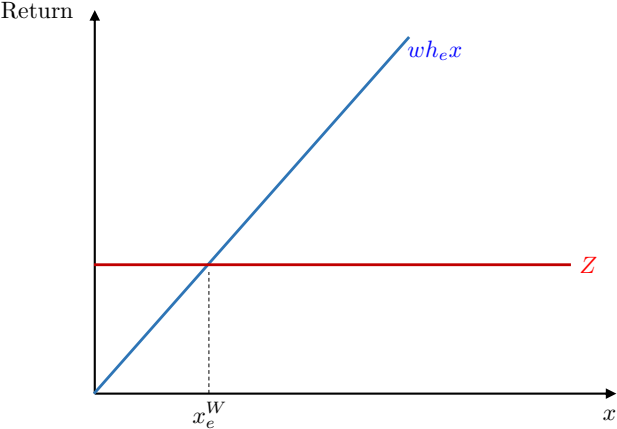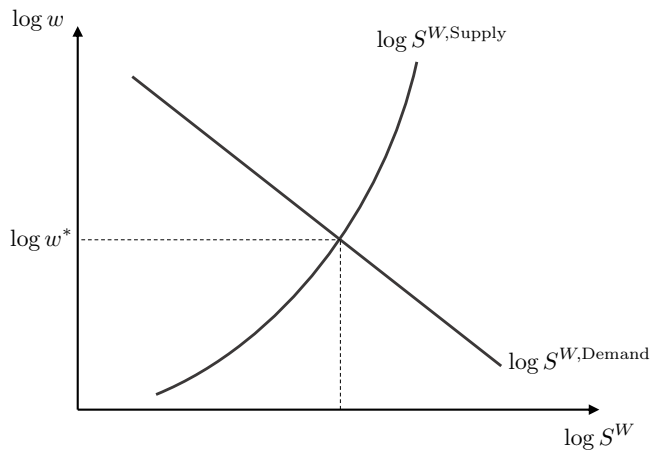
Occupational Shares

- Aggregate occupational shares

$$S^{\text{Wage Workers}} = g_W \left(\underset{+}{w} \right) \sum_e \sigma_e h_e^\alpha$$

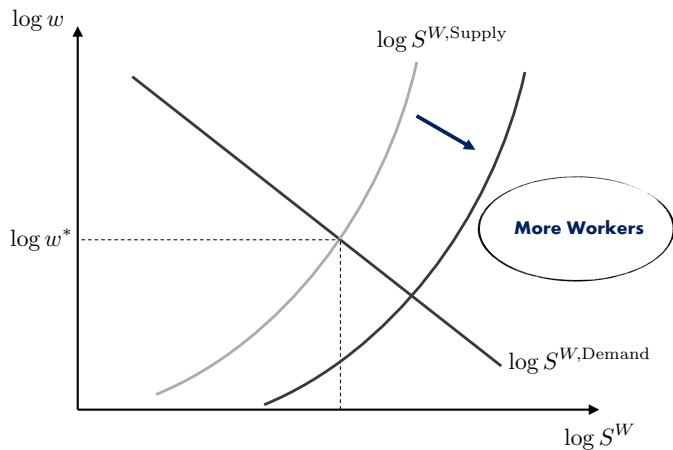$$S^{\text{Own Account}} = 1 - g_W \left(\underset{+}{w} \right) \sum_e \sigma_e h_e^\alpha$$

- Structural effect $\neq$ Occupational accounting if w changes

Labor Market Equilibrium (Fixed Managerial Pool)

Labor Market Equilibrium (Fixed Managerial Pool)

Occupational Accounting < Structural Effect

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Proposition

Suppose $\sum_e \sigma_{e,R} h_{e,c} > \sigma_{e,c} h_{e,c}$. Then,

$$S_c^{\text{Wage Worker,ACC}} > S_c^{\text{WageWorker,MODEL}}$$
$$S_c^{\text{Own Account,ACC}} < S_c^{\text{OwnAccountMODEL}}$$

- Fixed managerial pool $\rightarrow$ no increase in labor demand
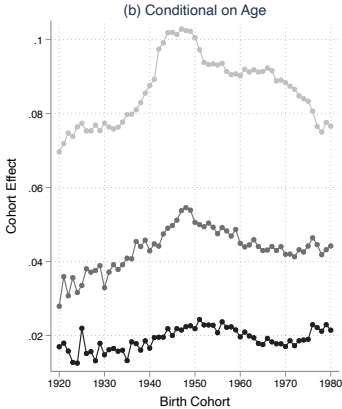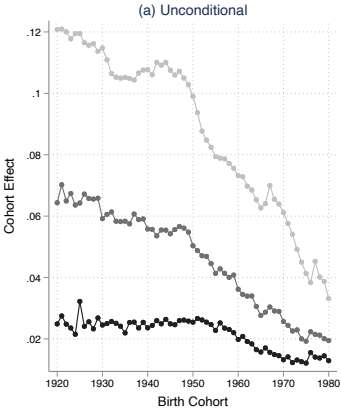
Accounting for Cohort Effects

- Cohort-level dataset on occupational shares

- Separately by income group, estimate for cohort c, in country i, year t and occupation j

$$S_{c,i,t}^{j} = \alpha + \beta_t + \gamma_i + \delta_{i,c} + \zeta' X_{c,i,t} + \varepsilon_{c,i,t}$$

where $\zeta' X_{c,i,t} = \zeta_1(a - 50)^2 + \zeta_2(a - 50)^3$ and $a = t - c$

- Display estimated cohort effects Back

Cohort Effects - Managers

(a) Unconditional   (b) Conditional on Age

High Income   Mid Income   Low Income

Related Literature

▸ **Development and the Organization of Production**: Gollin (2007), Guner et al (2008), Restuccia and Rogerson (2008), Buera et al (2015), Poschke (2013, 2018, 2022), Hjort et al (2022)

▸ **Human Capital and Structural Transformation**: Caselli and Coleman (2001), Galor (2005), Herrendorf and Schoellman (2018), Buera et al (2022), Porzio et al (2022)

▸ **Human Capital and Development Accounting**: Hall and Jones (1999), Caselli (2005), Jones (2014), Hendricks and Schoellman (2018, 2022), Rossi (2022)

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- **Development and the Organization of Production**: Gollin (2007), Guner et al (2008), Restuccia and Rogerson (2008), Buera et al (2015), Poschke (2013, 2018, 2022), Hjort et al (2022)

    - Mostly on frictions and technological change
    - This project → the role of skills

- **Human Capital and Structural Transformation**: Caselli and Coleman (2001), Galor (2005), Herrendorf and Schoellman (2018), Buera et al (2022), Porzio et al (2022)

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- **Human Capital and Structural Transformation**: Caselli and Coleman (2001), Galor (2005), Herrendorf and Schoellman (2018), Buera et al (2022), Porzio et al (2022)

  - Emphasizes cross-sector differences in skill intensity

  - This project $\rightarrow$ skills and occupational structure (within sectors)

- **Human Capital and Development Accounting**: Hall and Jones (1999), Caselli (2005), Jones (2014), Hendricks and Schoellman (2018, 2022), Rossi (2022)

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  - Relies on wages to discipline productivities
  - This project → skill-based sorting into wage employment

Occupational Choice - Low Education Group
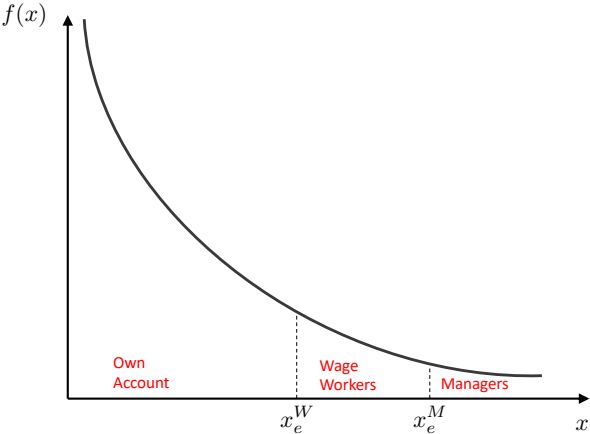
Occupational Choice - High Education Group
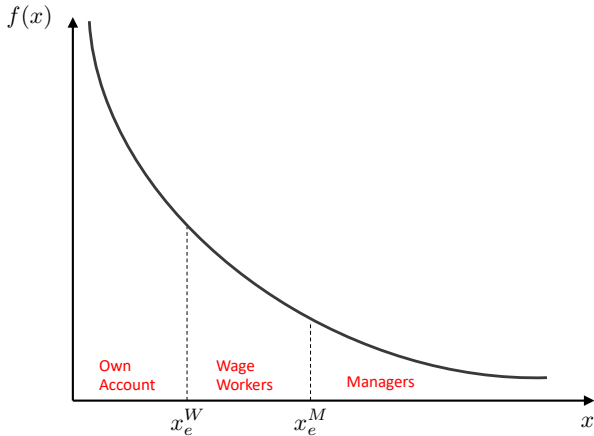
Occupational Shares in General Equilibrium

▸ Occupational shares by education

$$S_e^{\text{Managers}} = g\left(\underset{+}{A/Z}\right) h_e^{\alpha}$$

$$S_e^{\text{Wage Workers}} = \lambda g\left(\underset{+}{A/Z}\right) h_e^{\alpha}$$

$$S_e^{\text{Own Account}} = 1 - (1 + \lambda)\, g\left(\underset{+}{A/Z}\right) h_e^{\alpha}$$

were $\lambda = \lambda(\alpha, \gamma)$ is a constant

▸ $\uparrow A/Z \rightarrow \uparrow$ wage employment across all edu groups

Back

Fixing Edu Shares

- Consider accounting counterfactual

$$S_c^{j,\text{ACC}} = \sum_e \sigma_{e,c} S_{e,R}^j$$

- Assume $\alpha, \gamma, \{h_e\}_{e=1}^E$ common across countries

Proposition

$S_c^{j,ACC} = S_c^{j,MODEL}$ for each occupation j if $A_R/Z_R = A_P/Z_P$.

$\rightarrow$ Occupational transformation by education group captures effects of uneven tech change

Back

Development Accounting

- π_e = average earnings of *wage employed* in edu group e

$$\pi_e = \frac{S_e^W}{S_e^W + S_e^M} w h_e E[x | \bar{x}_W^e \leqslant x \leqslant \bar{x}_M^e] +$$
$$+ \frac{S_e^M}{S_e^W + S_e^M} \Lambda h_e^{\frac{1}{1-\gamma}} E[x^{\frac{1}{1-\gamma}} | x \geqslant \bar{x}_M^e]$$

Development Accounting

- π_e = average earnings of *wage employed* in edu group e

$$\pi_e = \underbrace{\frac{S_e^W}{S_e^W + S_e^M}}_{\text{Constant}} wh_e E[x|\bar{x}_W^e \leqslant x \leqslant \bar{x}_M^e] +$$

$$+ \underbrace{\frac{S_e^M}{S_e^W + S_e^M}}_{\text{Constant}} \Lambda h_e^{\frac{1}{1-\gamma}} E[x^{\frac{1}{1-\gamma}}|x \geqslant \bar{x}_M^e]$$

- Worker and managerial shares scale up proportionally across edu groups

Development Accounting

- π_e = average earnings of *wage employed* in edu group e

$$\bar{\pi}_e = \frac{S_e^W}{S_e^W + S_e^M} w \underbrace{h_e E[x \mid \bar{x}_W^e \leqslant x \leqslant \bar{x}_M^e]}_{\text{Constant}} +$$

$$+ \frac{S_e^M}{S_e^W + S_e^M} \Lambda \underbrace{h_e^{\frac{1}{1-\gamma}} E[x^{\frac{1}{1-\gamma}} \mid x \geqslant \bar{x}_M^e]}_{\text{Constant}}$$

- Higher h_e → lower thresholds $\bar{x}_W^e$ and $\bar{x}_M^e$ → lower average x conditional on wage employment

Cross-Sector Returns to Schooling

Two Special Cases

1. No own account option ($Z = 0$)
   → ↑ w counteracts increase in labor demand `Show`

2. Fixed pool of managers
   → ↓ w counteracts increase in labor supply `Show`

Occupational Accounting over Time

Does schooling account for changes in occupational shares over time?

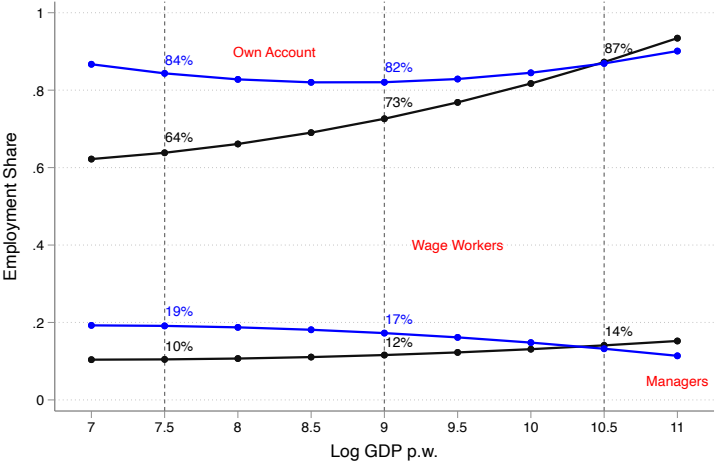# Occupational Accounting - Brazil
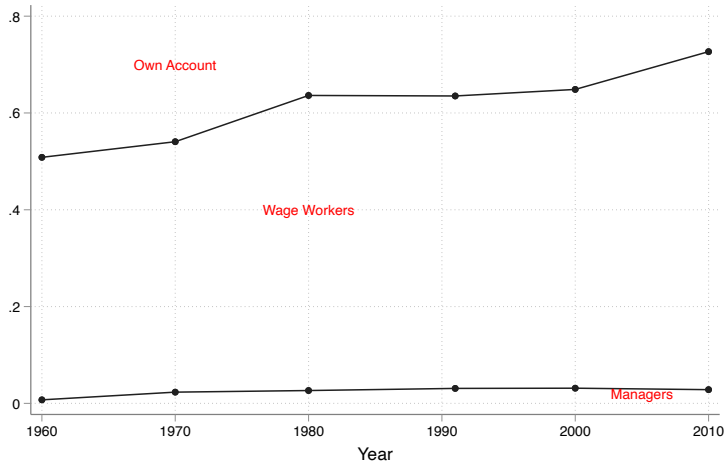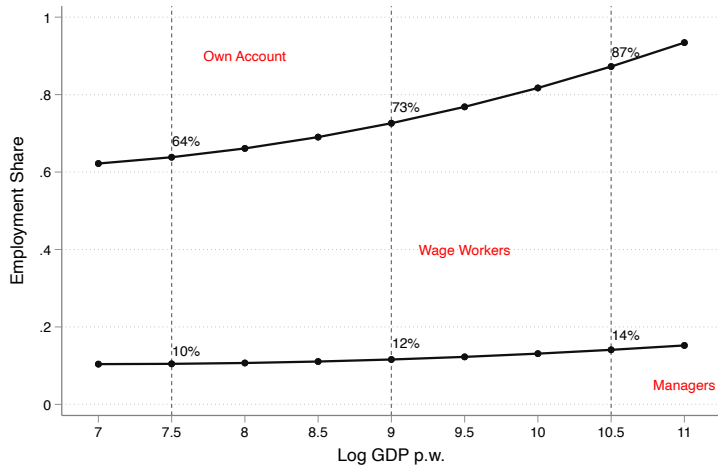
Occupational Accounting - Brazil

Occupational Accounting Over Time - All Countries

Show Regression

Occupational Accounting Over Time - All Countries

Figure axes: Y-axis "Employment Share" (0 to 1), X-axis "Log GDP p.w." (7 to 11)

Labels: Own Account, Wage Workers, Managers

Blue line (Own Account / upper): 84%, 82%
Black line (upper): 64%, 73%, 87%
Blue line (lower): 19%, 17%
Black line (lower): 10%, 12%, 14%

Back

Show Regression

Occupational Structure by Cohort

Which cohorts drive changes in the occupational structure?
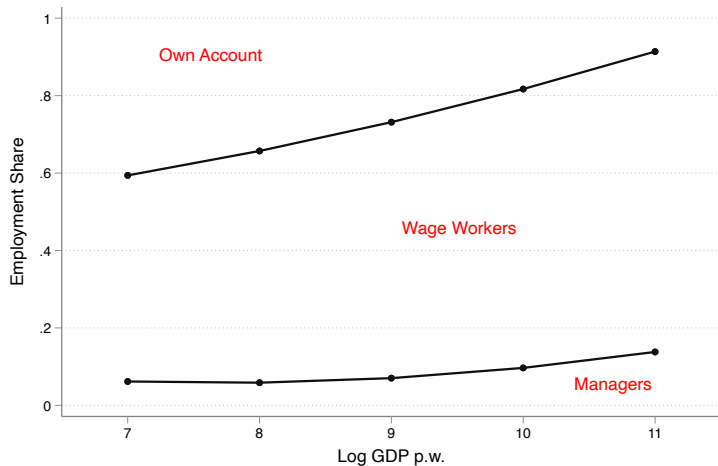
Wage Employment by Cohort - Brazil 2010
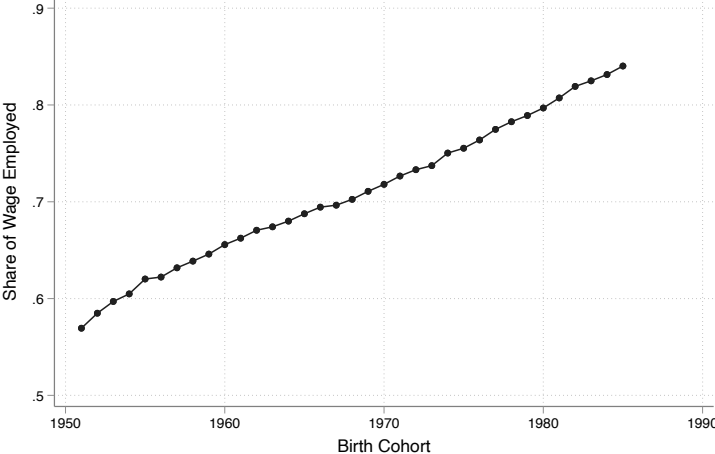
Wage Employment by Cohort - All Countries

(a) Unconditional

(b) With Age Controls

High Income ● Mid Income ● Low Income

Details Managers

Occupational Structure Accounting - Cohort Effects

Figure: Line chart with x-axis "Log GDP p.w." (7 to 11) and y-axis "Employment Share" (0 to 1). Top curve labeled "Own Account" rising from about .6 to .9. Bottom curve labeled "Managers" rising slightly from about .06 to .14. Label "Wage Workers" in the middle.
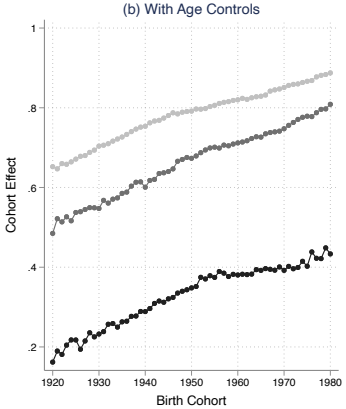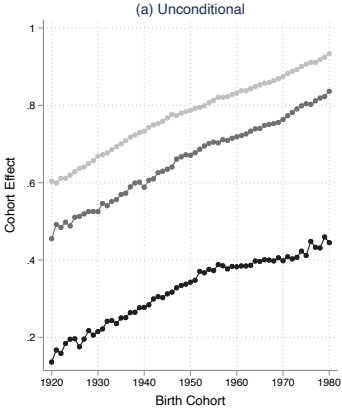
Show Regression

Occupational Structure Accounting - Cohort Effects

Show Regression

Back

Cohort Effects & Schooling - All Countries

(a) Wage Employed

(b) Years of Schooling
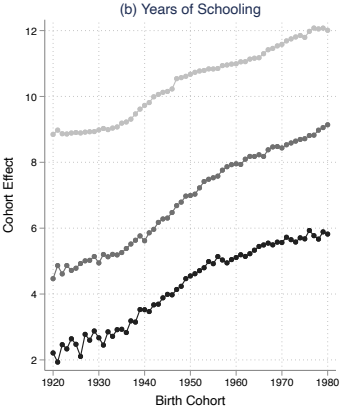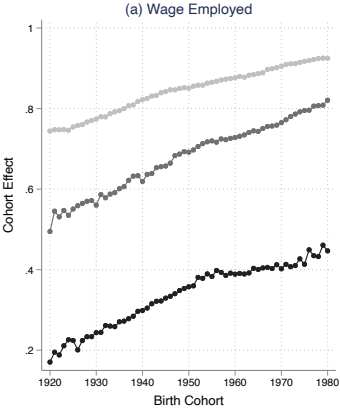
High Income — Mid Income — Low Income

1. Regression with Trends across Cohorts

- Estimate for cohort c, in country i, year t and occupation j

$$S^j_{c,i,t} = \alpha + \beta \text{YrsSch}_{c,i} + \gamma_t + \delta_i + \theta^1_i c + \theta^2_i c^2 + \zeta' X_{c,i,t} + \varepsilon_{c,i,t}$$

- Cohort-level trends $\rightarrow$ slow-moving factors affecting schooling and occupational choices

- $X_{c,i,t}$ includes controls for age

- Restriction: age effects flat around 50 (robust to alternatives)

Results

	Own Account	Wage Workers	Managers
Years of Schooling	−0.035***	0.028***	0.007***
	(0.001)	(0.001)	(0.001)
N	8155	8155	8155
Age Controls	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes
Country × Cohort Trends	Yes	Yes	Yes

- Δ Years of schooling ≈ 8 between and High-Income and Low-Income
  - → own account ↓ 28%, wage workers ↑ 22%, managers ↑ 6% in low-income when closing schooling gap

Back

2. Evidence from INPRES

- INPRES → primary school construction program in Indonesia (1974-1978)

- As in Duflo (2001), exploit variation in

  - Intensity of program by district
  - Exposure across cohorts (only young enough fully treated)

- We estimate for individual i in cohort c and district d

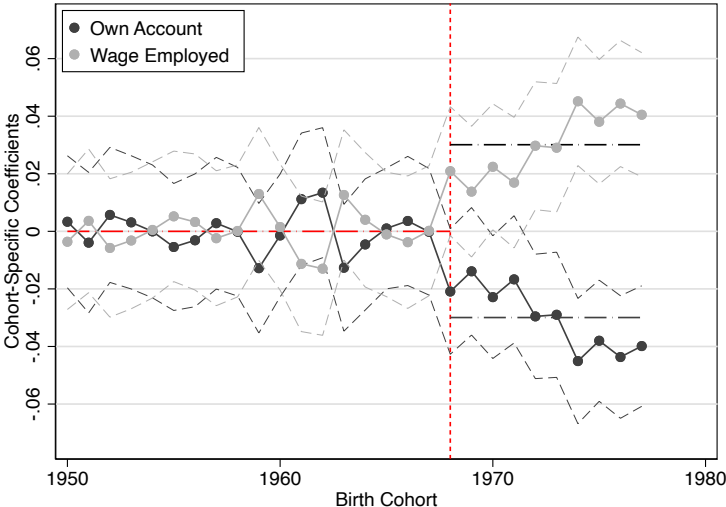$$y_{i,c,d} = \alpha_c + \eta_d + \sum_{k=1950}^{1977} \delta_k T_d \mathbb{1}\left(k = c\right) + \varepsilon_{i,c,d}$$

where T_d = number of built schools per pupil in district d

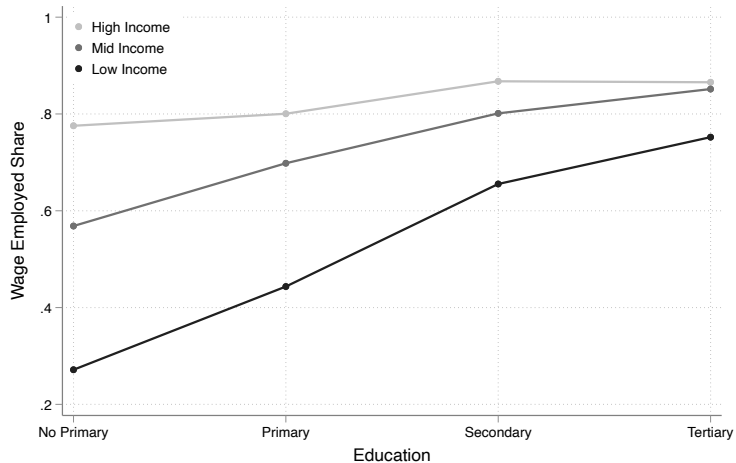# Indonesia - Schooling Results
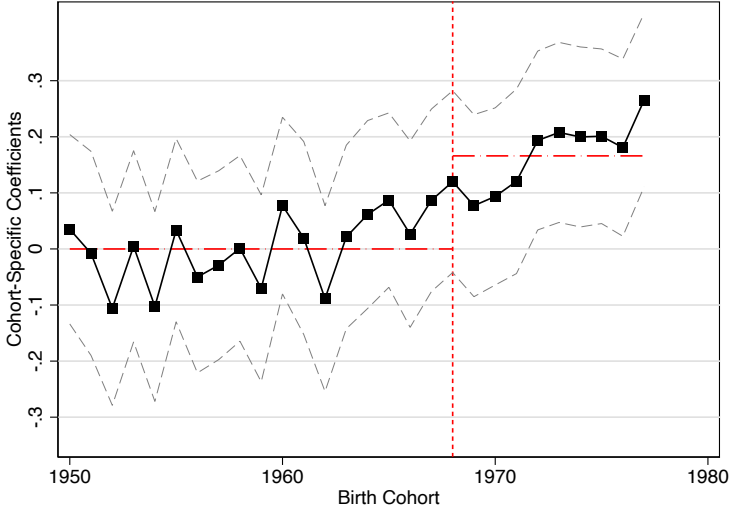
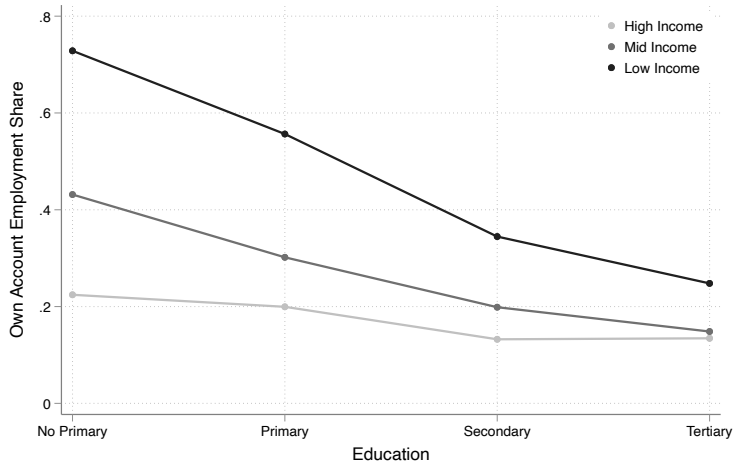# Indonesia - Employment Results

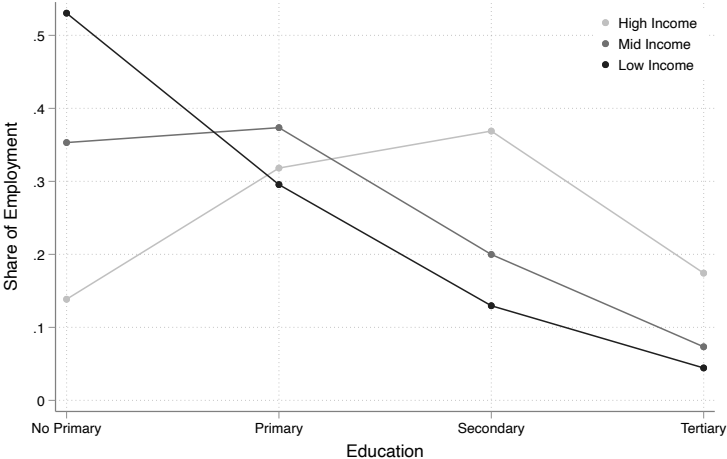# Indonesia - Employment Results
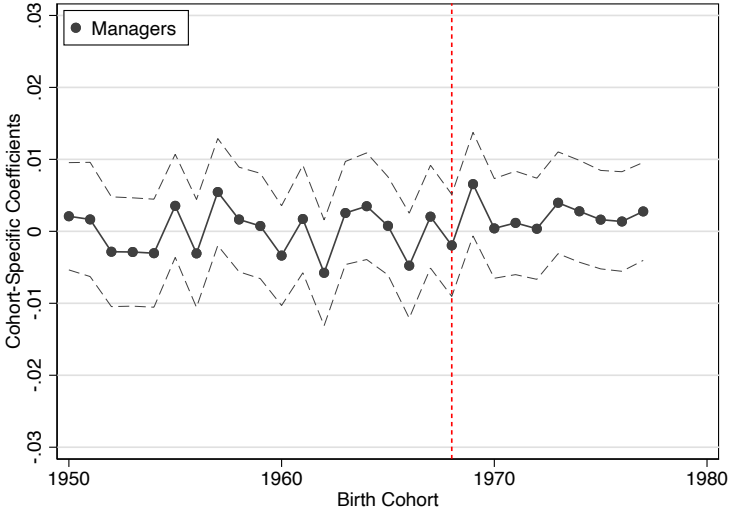
Educational Profiles - Managers
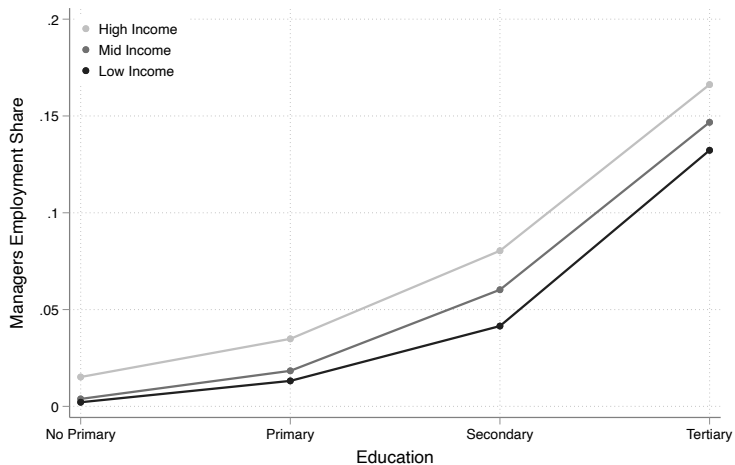
Educational Profiles - Wage Employed

Educational Profiles - Own Account

Education Distribution across Countries

Occupational Shares in Partial Equilibrium

- Aggregate occupational shares

$$S^{\text{Managers}} = g_M \left(\underset{-}{w} \right) \sum_e \sigma_e h_e^{\alpha}$$
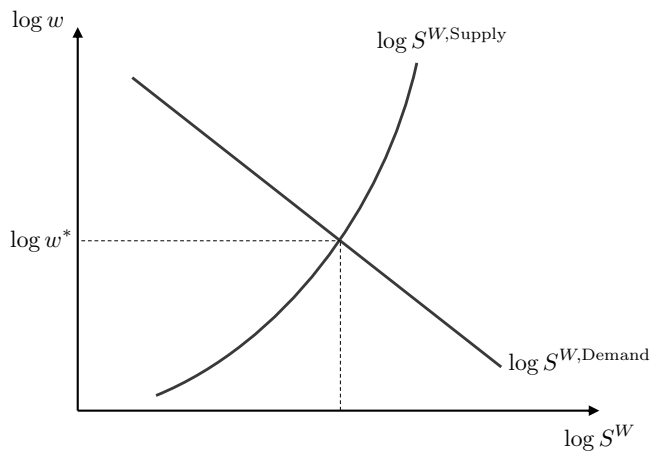
$$S^{\text{Wage Workers}} = g_W \left(\underset{+}{w} \right) \sum_e \sigma_e h_e^{\alpha}$$

$$S^{\text{Own Account}} = 1 - \left[g_M \left(\underset{-}{w} \right) + g_W \left(\underset{+}{w} \right) \right] \sum_e \sigma_e h_e^{\alpha}$$
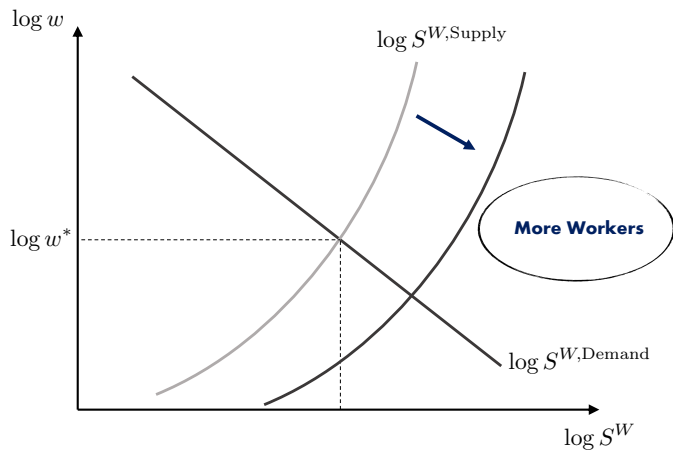
- Occupational Accounting $\rightarrow$ changes distribution of σ_e keeping w fixed

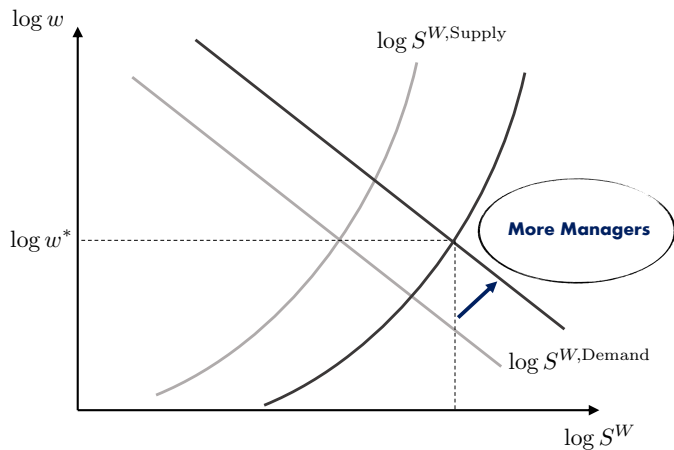- Structural effect $\neq$ Occupational accounting if w changes

Labor Market Equilibrium

Labor Market Equilibrium: ↑ Education

Labor Market Equilibrium: ↑ Education

Occupational Accounting = Structural Effect

- Consider change in educational shares to $\sigma_{e,R}$

- Compare accounting counterfactual $\boxed{\text{Fixing Edu Shares}}$

$$S_c^{j,\text{ACC}} = \sum_e \sigma_{e,R} S_{e,c}^j$$

with model-based counterfactual $S_c^{j,\text{MODEL}}$

Proposition

$S_c^{j,ACC} = S_c^{j,MODEL}$ *for each occupation j.*

$\rightarrow$ More educated workforce creates both supply and demand for wage labour