

# Educational Investment in Spatial Equilibrium: Evidence from Indonesia

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# How does migration shape large-scale educational investment?

- Governments invest \$3 trillion in education annually (World Bank 2022)
  - In Indonesia, 61,807 new primary schools (Sekolah Dasar INPRES program, 1973-1978)
- Educational investment targets students locally
  - But graduates migrate and seek employment nationally

# This paper

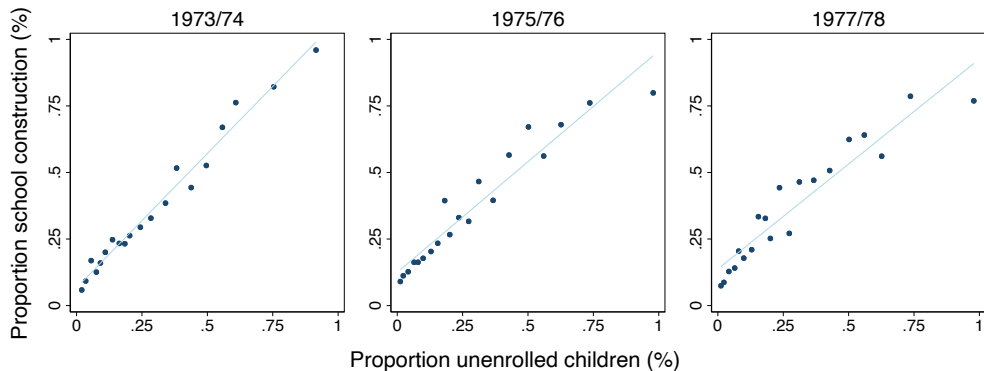
- **Aggregate and distributional effects** of the INPRES program
  - Difference-in-difference with long-run outcomes (Duflo 2001)
  - Spatial heterogeneity in returns to education + implications for program design
- Spatial equilibrium model of **complementary education + migration** decisions
  - Returns to education: rural incentives depend on urban wages (if mobile)
  - Regional convergence: rural schools increase urban output (if mobile)
- **Results:** aggregate output  $\uparrow$  (8%), inequality  $\downarrow$  (people  $\downarrow$  5%, places  $\uparrow$  12%)
  - Mobility magnifies each effect

# Literature

- **Education and migration** at scale in general equilibrium
  - Education: Khanna 2021, Dinerstein et al. 2022 (no migration)
  - Migration: Dahl 2002, Bryan et al. 2014, Bryan & Morten 2019 (no education)
  - Both: Eckert & Kleineberg 2021, Agostinelli et al. 2022 (no school construction)
- **INPRES program** evaluation with aggregate effects and counterfactuals
  - Duflo 2001/2004, Martinez-Bravo 2017, Ashraf et al. 2020, Bazzi et al. 2021
- **Place-based policy** with portable human capital benefits
  - Glaeser & Gottlieb 2008, Kline & Moretti 2014, Busso et al. 2013, Austin et al. 2018

# Data and Stylized Facts

## The INPRES program built 62,000 new primary school (1973-1978)



KEAMANAN  
KEBERSIHAN  
KETERTIBAN  
KEINDAHAN  
KEKELUARGAAN  
KERINDANGAN  
KESEHATAN  
KEDISIPLINAN  
KERAPIHAN  
KEWASPADAAN

10 K  
Kebersihan, Ketertiban, Keindahan, Kekeluargaan, Kerindangan, Kesehatan, Kedisiplinan, Kerapihan, Kewaspadaan



# Data

- **Treatment** at district level
  - INPRES school construction (1973-1978)
  - Pre-program primary schools, child populations, enrollment rates
- **Long-run outcomes** at individual level
  - SUSENAS household surveys (2011-2014)
  - Districts of residence and birth, years of schooling, monthly wages



## Difference-in-difference variation in school construction (Duflo 2001)

$$Y_{ijk} = \delta_j + \delta_k + \beta S_j T_k + \mathbf{C}_j T_k \boldsymbol{\phi} + \varepsilon_{ijk}$$

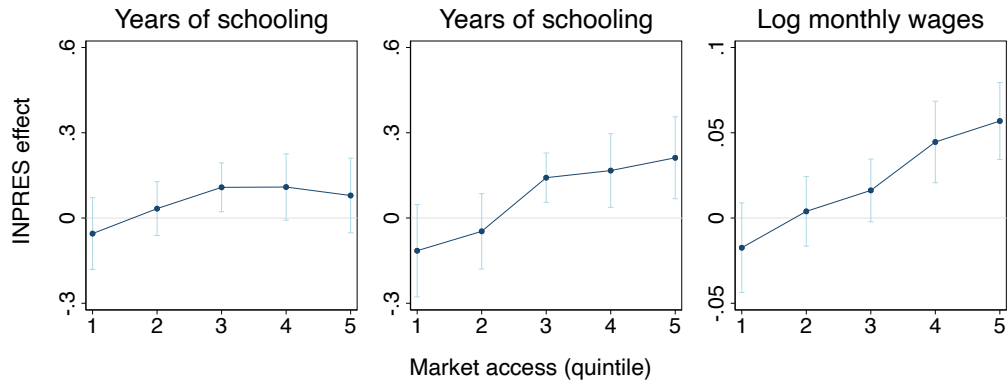
$$Y_{ijk} = \delta_j + \delta_k + \mathbf{X}_j S_j T_k \boldsymbol{\beta} + \mathbf{C}_j T_k \boldsymbol{\phi} + \varepsilon_{ijk}$$

- **Young vs. old** students in age cohorts  $k$ 
  - Young exposed to new schools, but old not
- **Many vs. few** new schools in origin districts  $j$ 
  - More schools  $\rightarrow$  bigger difference between young and old cohorts

## Long-term education and wage effects

Outcomes	Estimate	SE	Obs
Years of schooling	0.103**	(0.0424)	233,517
— For wage earners	0.121**	(0.0495)	89,404
Log monthly wages	0.0195**	(0.00916)	89,404

## Driven by labor market access



Model

# Spatial equilibrium model

- ① Government constructs schools
  - Build human capital that is portable (aggregate output)
- ② Individuals invest in education
  - In a district, more schools → better access → lower costs of education
- ③ Individuals migrate for work
  - Mobility gives rural students access to high urban wages (person-based inequality)
  - But rural students leave after graduation (place-based inequality)

## Education and migration frictions

$$U(e, \epsilon) = \alpha_\ell \epsilon_{jkl}^\alpha \underbrace{\left[ (1 - \widehat{\tau_{j\ell}^m}) w_\ell h_{jk} \epsilon_{jkl}^h e^\eta \epsilon \right]}_{\text{net labor income}} - \underbrace{(1 + \widehat{\tau_{jk}^e}) c \epsilon_{jkl}^c e}_{\text{cost of education}}$$

- Individual  $i$ , origin  $j$ , age cohort  $k$ , destinations  $\ell$ 
  - For  $ijk$ , each destination has  $e_\ell^*(\epsilon_\ell) = \max_e U_\ell(e, \epsilon_\ell)$  and  $U_\ell(\epsilon_\ell) = U_\ell(e_\ell^*, \epsilon_\ell)$
- Compare destinations, then pick best to get choice probabilities

$$\pi_{jkl} = \frac{\tilde{w}_{jkl}^\theta}{\sum_{\hat{\ell}} \tilde{w}_{jk\hat{\ell}}^\theta} \quad \text{for} \quad \tilde{w}_{jkl} \equiv \alpha_\ell^{1-\eta} (1 - \widehat{\tau_{j\ell}^m}) w_\ell \tilde{\epsilon}_{jkl}$$

# Choice probabilities, education, and wages

- LHS variables observed in data

$$\pi_{jkl} = \tilde{w}_{jkl}^\theta / \sum_{\hat{\ell}} \tilde{w}_{jk\hat{\ell}}^\theta$$

$$\overline{\text{educ}}_{jkl} = \mathbb{E}[e^* \mid \text{individuals choose } \ell]$$

$$\overline{\text{wage}}_{jkl} = \mathbb{E}[w_\ell h_{jk} \varepsilon_{jkl}^h e^\eta \epsilon \mid \text{individuals choose } \ell, e = e^*]$$

- Education and wages are increasing in labor market access

$$\overline{\text{educ}}_{jkl}, \overline{\text{wage}}_{jkl} \propto \left( \sum_{\hat{\ell}} \tilde{w}_{jk\hat{\ell}}^\theta \right)^{\frac{1}{\theta(1-\eta)}} \equiv \text{MA}_{jk}$$

# Estimation



## Human capital function (INPRES as IV)

$$\text{wage}_i \propto \text{hcap}_i = (\text{educ}_i)^\eta$$

$\Downarrow$

$$\log \text{wage}_{ijk} = \delta_j + \delta_k + \eta \log \text{educ}_{ijk} + \mathbf{C}_j T_k \boldsymbol{\phi} + \varepsilon_{ijk}$$

$$\log \text{educ}_{ijk} = \delta_j + \delta_k + \beta S_j T_k + \mathbf{C}_j T_k \boldsymbol{\phi} + \varepsilon_{ijk}$$

$\Downarrow$

$$\hat{\eta} = 0.688^{**}(0.311)$$

## Education and migration costs (INPRES as DD)

$$1 + \tau_{jk}^e = (1 + S_j T_k)^{-\beta} \delta_j \delta_k (1 + C_j T_k)^\phi$$

$$1 - \tau_{j\ell}^m = (1 + d_{j\ell}^P)^{-\varphi_1} (1 + d_{j\ell}^D)^{-\varphi_2}$$

$\Downarrow$

$$\begin{aligned} \log \overline{\text{educ}}_{jkl} - \log \overline{\text{wage}}_{jkl} &= \beta \log(1 + S_j T_k) - \log \delta_j - \log \delta_k - \phi \log(1 + C_j T_k) \\ &\quad - \varphi_1 \log(1 + d_{j\ell}^P) - \varphi_2 \log(1 + d_{j\ell}^D) + \log \frac{\eta}{c} - \log \varepsilon_{jkl}^c \end{aligned}$$

$\Downarrow$

$$\hat{\beta} = 0.110^{**}(0.047), \quad \hat{\varphi}_1 = 0.042^{***}(0.004), \quad \hat{\varphi}_2 = 0.018 (0.050)$$

## Other parameters (INPRES as moments)

$$\sum_{i=1}^n [y_i - \exp(x_i \hat{\beta})] x_i = 0$$

- Poisson pseudo-maximum likelihood (Santos Silva & Tenreyro 2006)
  - Common in spatial models to accommodate zeros in choice probabilities

$$\log \overline{\text{educ}}_{jkl} - \log \overline{\text{wage}}_{jkl}$$
$$\Delta_\ell \log \overline{\text{educ}}_{jkl}, \quad \Delta_\ell \log \overline{\text{wage}}_{jkl}, \quad \Delta_\ell \log \pi_{jkl}$$

INPRES treatment effects

# Counterfactuals

# Quantifying aggregate and distributional effects

- **Evaluate** relative to zero-construction counterfactual
- **Decompose** effects of mobility by mechanism
  - And separate each from the general equilibrium effects
  - Diff-in-diff avoids model but only captures net effects
- Study program **design**
  - By simulating alternative allocations of school construction

The program increased aggregate output by 8%

	Aggregate output
Zero construction	<b>1.00</b>
+ Direct effect of construction	1.02
+ Migration	1.03
+ Migration-induced schooling	1.07
+ New equilibrium wages	<b>1.08</b>

- Small gains without migration (direct effect) or without education (sorting)
  - Complementarity between education and migration
  - Gains from sorting are already large (Bryan et al. 2014)

## With especially large benefits for rural students

	Inequality (people)
Zero construction	<b>1.00</b>
+ Direct effect of construction	0.99
+ Migration	0.98
+ Migration-induced schooling	0.96
+ New equilibrium wages	<b>0.95</b>

- Expanded opportunity for rural students with high marginal returns
  - Decreased inequality between rural and urban students by 5%

But also increased inequality across places by 12%

	Inequality (places)
Zero construction	<b>1.00</b>
+ Direct effect of construction	0.99
+ Migration	1.02
+ Migration-induced schooling	1.11
+ New equilibrium wages	<b>1.12</b>

- The program explicitly aimed to encourage regional convergence
  - But mobility places convergence in tension with output gains
  - Rural regions still enjoy net gains, but urban regions gain more



## Equity-efficiency tradeoff under mobility

	Aggregate output	Inequality (people)	Inequality (places)
Actual INPRES allocation	1.08	0.95	1.12
Prioritizing rural regions	<b>1.09</b>	0.93	<b>1.14</b>
+ Halving migration costs	<b>1.13</b>	0.90	<b>1.18</b>
Prioritizing urban regions	1.04	0.97	1.06
+ Halving migration costs	1.08	0.93	1.12

- Rural construction generates large returns but widens rural-urban gap (still Pareto)
- Alternative: schools + roads, although rural out-migration will rise (not Pareto)

## Conclusion

# Summary

- Evaluating large-scale educational investment in spatial equilibrium
  - Indonesia's INPRES program built 62,000 primary schools in 1970s
  - Aggregate output  $\uparrow$  (8%), person-based inequality  $\downarrow$  (5%), place-based  $\uparrow$  (12%)
- Education and migration are **complementary**
  - Big gains for rural students who leave rural regions behind