Educational Investment in Spatial Equilibrium: Evidence from Indonesia

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How does migration shape educational investment?

- Governments invest $3 trillion in education annually (World Bank 2022)
  - In Indonesia, 61,807 new primary schools (INPRES 1973-1978)

- Schools serve students locally, but graduates seek employment nationally
  1. Non-local incentives for individual investment
  2. Non-local effects of collective investment (at scale)

This paper

- Aggregate and distributional effects of the **INPRES program**
  - Difference-in-difference with long-run outcomes (Duflo 2001)
  - Spatial equilibrium model to decompose effects and redesign program

- **Complementarity between education and migration**
  1. Rural schooling depends on urban wages (non-local incentives)
  2. Rural schools increase urban output (non-local effects)

- Results: aggregate output $\uparrow$ (8%), inequality $\updownarrow$ (people $\downarrow$ 5%, places $\uparrow$ 12%)
  - Tension between returns to education and regional convergence

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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

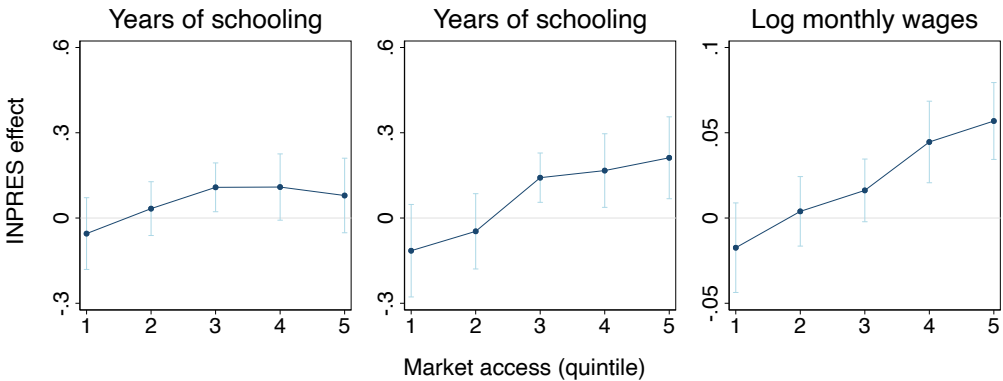
Data and identification

- **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-differences** (Duflo 2001)
  - **Young vs. old** age cohorts given **more vs. less** construction in birth district

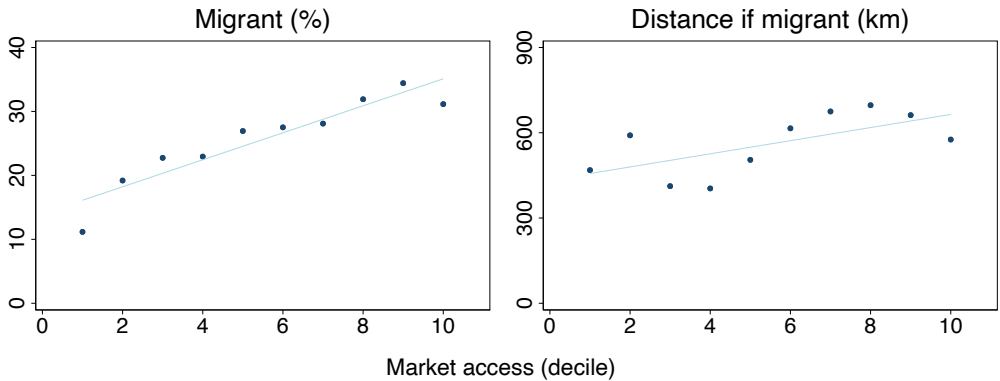
Long-term education and wage effects

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 (non-local incentives)



Migration rates are high (non-local effects)



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 $\rightarrow$ better access $\rightarrow$ 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

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

(migration: $\widetilde{\tau^{m}_{j\ell}}$; education: $\widetilde{\tau^{e}_{jk}}$)

- Individual i, origin j, age cohort k, destinations ℓ
  - Each destination has $e^*_\ell(\epsilon_\ell) = \max_e U_\ell(e, \epsilon_\ell) \;\Rightarrow\; U_\ell(\epsilon_\ell) = U_\ell(e^*_\ell, \epsilon_\ell)$
  - Compare $U_\ell(\epsilon_\ell)$ across destinations, then pick best

- Model predicts education, migration, and wages

Estimation

1. Human capital function (INPRES as IV)

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

$$\Downarrow$$

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

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

$$\Downarrow$$

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

2. Education and migration costs (INPRES as DD)

$$1 + \tau^{e}_{jk} = (1 + S_j T_k)^{-\beta} \delta_j \delta_k (1 + \boldsymbol{C}_j T_k)^{\boldsymbol{\phi}}$$
$$1 - \tau^{m}_{j\ell} = (1 + d^{P}_{j\ell})^{-\varphi_1} (1 + d^{D}_{j\ell})^{-\varphi_2}$$

$$\Downarrow$$

$$\log \overline{\mathsf{educ}}_{jk\ell} - \log \overline{\mathsf{wage}}_{jk\ell} = \beta \log(1 + S_j T_k) - \log \delta_j - \log \delta_k - \boldsymbol{\phi} \log(1 + \boldsymbol{C}_j T_k) - \varphi_1 \log(1 + d^{P}_{j\ell}) - \varphi_2 \log(1 + d^{D}_{j\ell}) + \log \frac{\eta}{c} - \log \varepsilon^{c}_{jk\ell}$$

$$\Downarrow$$

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

3. 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)

$$\log \overline{\text{educ}}_{jk\ell} - \log \overline{\text{wage}}_{jk\ell}$$

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

INPRES treatment effects

Counterfactuals

Goals

- **Evaluate** relative to zero-construction counterfactual
  - Aggregate and distributional effects
- **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	**1.00**
+ Direct effect of construction	1.02
+ Migration	1.03
+ Migration-induced schooling	1.07
+ New equilibrium wages	**1.08**

- 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	**1.00**
+ INPRES construction	**0.95**

- 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	**1.00**
+ INPRES construction	**1.12**

- 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	**1.09**	0.93	**1.14**
+ Halving migration costs	**1.13**	0.90	**1.18**

- 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