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

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)

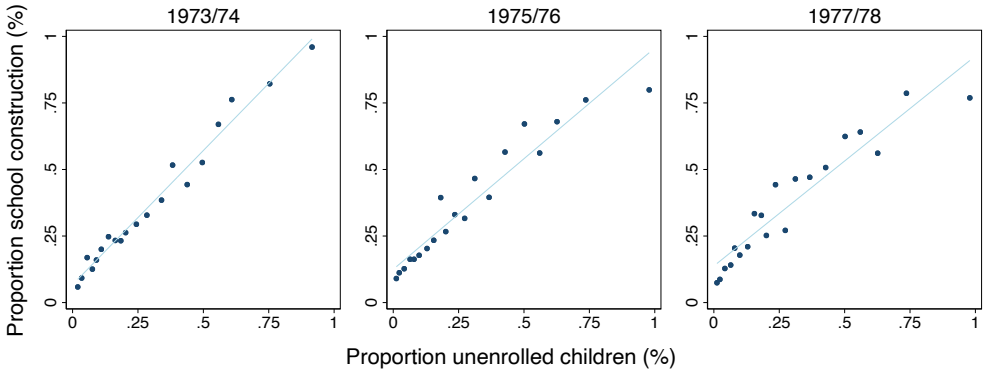
- **INPRES program** evaluation with aggregate effects and counterfactuals
  - Duflo 2001/2004, Martinez-Bravo 2017, Ashraf et al. 2020, Bazzi et al. 2021

- **Place-based policy** with portable human capital benefits
  - Glaeser & Gottlieb 2008, Kline & Moretti 2014, Busso et al. 2013, Austin et al. 2018

Data and Stylized Facts


KEAMANAN
KEBERSIHAN
KETERTIBAN
KEINDAHAN
KEKELUARGAAN
KERINDANGAN
KESEHATAN
KEDISIPLINAN
KERAPIHAN
KEWASPADAAN
SD INPRES DAYA
KEC. BIRINGKANAYA
KOTA MAKASSAR

INPRES built 62,000 new primary schools



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 (Duflo 2001)

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

1. **Young vs. old** students by age cohort k
2. **More vs. less** school construction by origin district j

Long-run education and wage effects

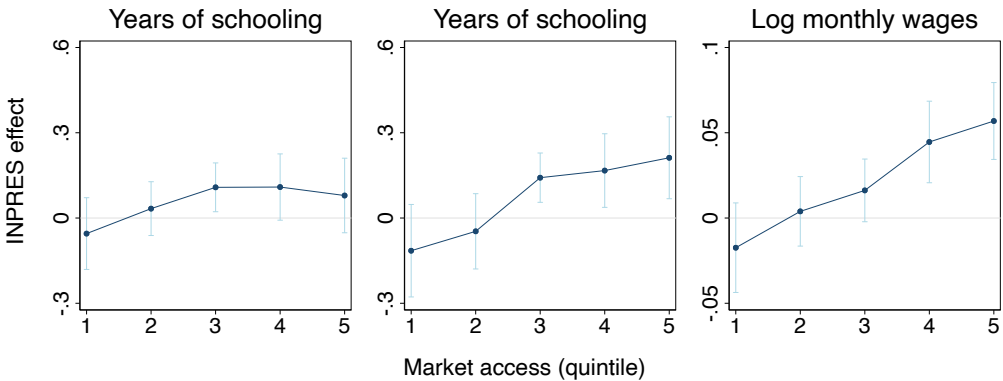
Outcomes	Estimate	SE	Obs
Years of schooling	0.103**	(0.0424)	233,517
— For wage earners	0.121**	(0.0495)	89,404
Log monthly wages	0.0195**	(0.00916)	89,404

Driven by labor market access (non-local incentives)

$$\text{MA}_d = \sum_{d'} \text{w}_{d'} \text{popden}_{d'} \quad \text{for} \quad \text{w}_{d'} \propto (1 + \text{dist}_{dd'})^{-2}$$

- Captures access to high urban wages
  - Population density in 1971 + Euclidean distances

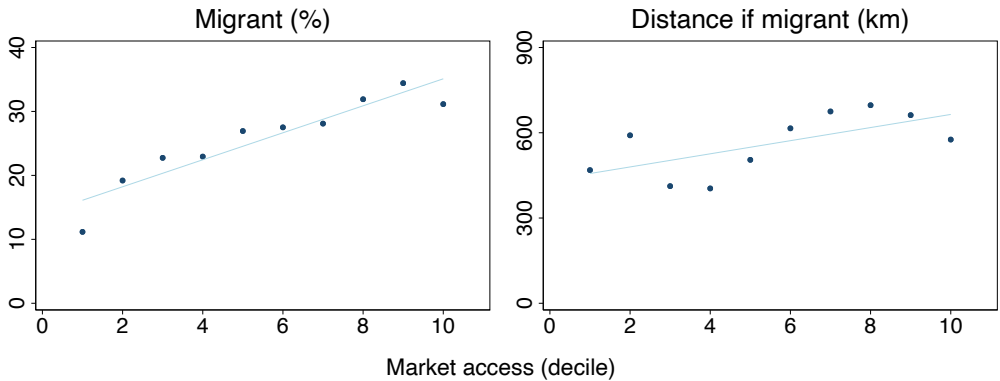
Driven by labor market access (non-local incentives)



Migration rates are high (non-local effects)

- Average migration rate of 26% and distance of 576 km
  - Increasing in labor market access
- Cross-province 16% vs. cross-state 31% in US (ACS 2013-2014)

Migration rates are high (non-local effects)



But INPRES does not directly increase migration

Outcomes	Estimate	SE	Obs
Migrant	0.0244	(0.0194)	244,793
Distance if migrant (km)	-5.097	(7.706)	62,717
Migrant to urban	0.0284	(0.0307)	242,646
Migrant to rural	0.0259	(0.0236)	244,793

- Non-local incentives and effects still apply
- Consistent with model: INPRES affects costs of education, not migration
- Counterfactuals: INPRES effects under different migration costs

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

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

(migration over $\tau_{j\ell}^{m}$; education over τ_{jk}^{e})

- Individual i, origin j, age cohort k, destinations ℓ
  - Each destination has $U_\ell(\epsilon_\ell) = \max_e U_\ell(e, \epsilon_\ell)$

- Compare destinations, then pick best to get choice probabilities

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

Choice probabilities, education, and wages

- Closed form for $\pi_{jk\ell}$, $\overline{\text{educ}}_{jk\ell}$, and $\overline{\text{wage}}_{jk\ell}$ (data)
  - In equilibrium, endogenous base wages w_ℓ and prices p_ℓ
  - Including agglomeration κ and congestion μ

- Education and wages are increasing in labor market access (endogenous)

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

Aggregate and distributional effects

- CES aggregate output

$$Y(a) = \left\{ \sum_{\ell} \left[A_\ell H_\ell(a_\ell) \right]^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}}$$

- Inequality (people vs. places)

$$D(a) = \lim_{\sigma \to \infty} \{ Y^U(a) - Y^R(a) \} \quad \text{for} \quad Y_\ell^U(a) = U_\ell Y_\ell(a)$$

Estimation

1. Human capital function (INPRES as IV)

$$\text{wage}_i = w_{\ell(i)}(\text{educ}_i)^{\eta}\epsilon_i$$

$$\Downarrow$$

$$\log \text{wage}_i = \log w_\ell + \eta \log \text{educ}_i + \log \epsilon_i$$

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

$$\Downarrow$$

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

2. Education and migration costs (INPRES as DD)

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

$$\Downarrow$$

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

$$\Downarrow$$

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

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)
  - Common in spatial models to accommodate zeros in choice probabilities
  - Calibrated agglomeration κ, congestion μ, substitution σ (Bryan & Morten 2019)

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

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**

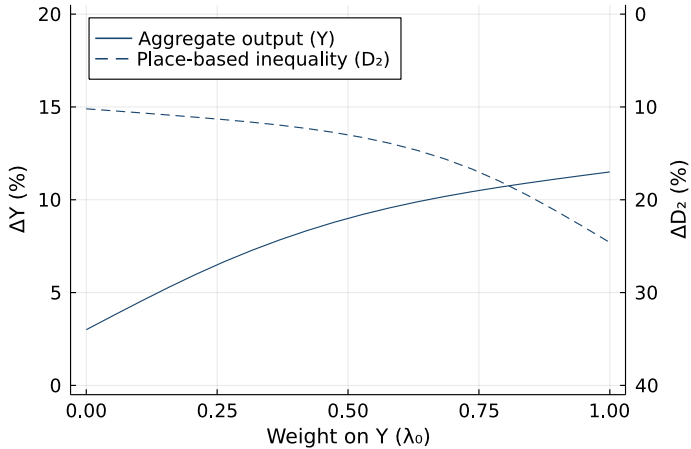
- Expanded opportunity for rural students with high marginal returns
  - Decreased inequality between rural and urban students by 5%

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 for policymaker



- Targeting rural areas: output ↑, but rural-urban gap ↑ (implied 50-50 weight)

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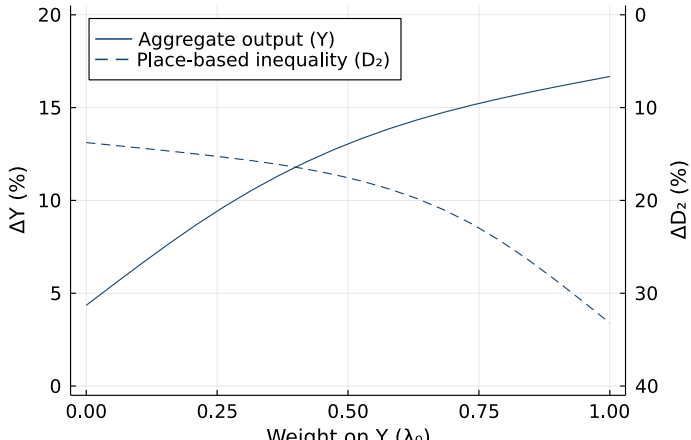

- Especially with schools + roads, which drain rural areas

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