

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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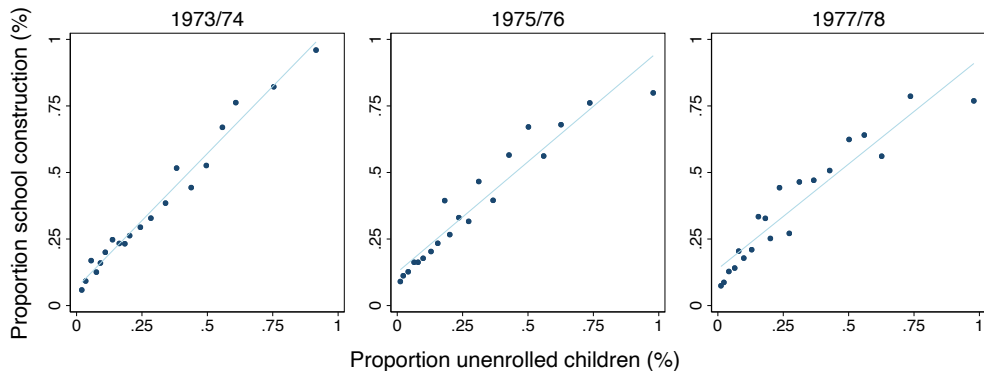
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Literature

- **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

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	Treatment		Obs
	Estimate	SE	
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

Long-term education and wage effects

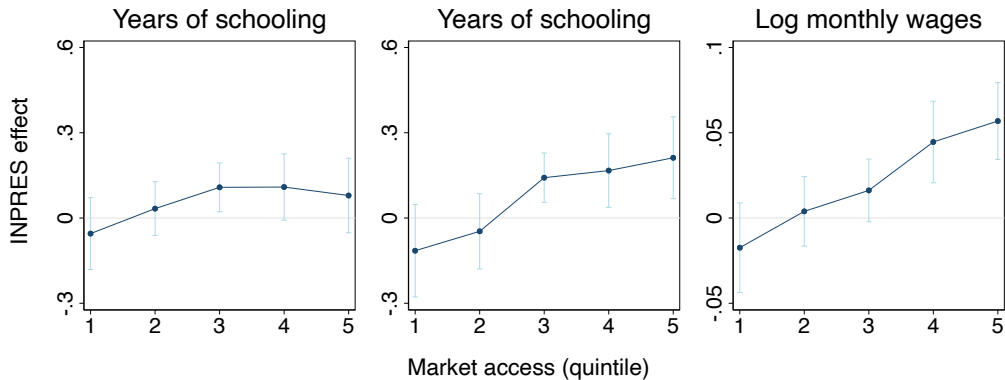
Outcomes	Placebo		
	Estimate	SE	Obs
Years of schooling	-0.0176	(0.0318)	196,308
— For wage earners	0.0120	(0.0566)	55,091
Log monthly wages	-0.00765	(0.00890)	55,091

Driven by labor market access (non-local incentives)

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

- Captures access to high urban wages
 - Population density in 1971 with inverse-distance weights

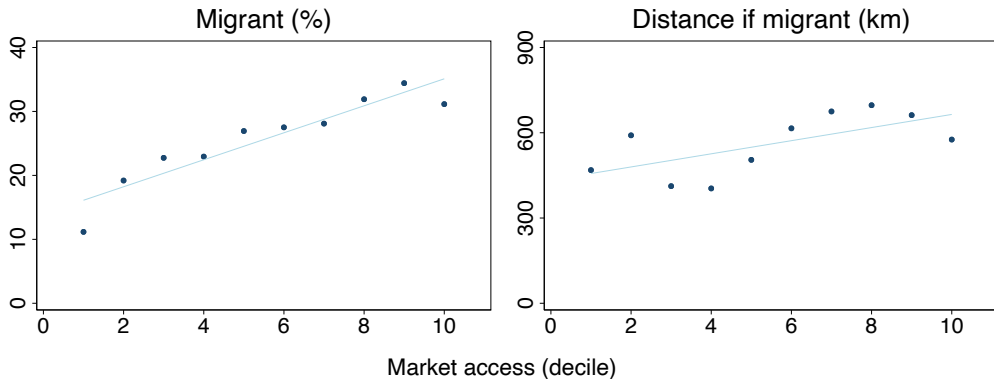
Driven by labor market access (non-local incentives)



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 change migration patterns

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 → 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 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 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

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

Aggregate and distributional effects

- CES aggregate output

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

- Inequality (people vs. places)

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

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

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
+ Direct effect of construction	0.99
+ Migration	0.98
+ Migration-induced schooling	0.96
+ New equilibrium wages	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
+ Direct effect of construction	0.99
+ Migration	1.02
+ Migration-induced schooling	1.11
+ New equilibrium wages	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
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