How to close the skill gap?

Parental Background and Children's Skill Development in Indonesia

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Motivation

- Parental investments are an important determinant of human capital
- In the context of developing countries, not only education, but also nutrition investments play a role

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- Parental investments are an important determinant of human capital
- In the context of developing countries, not only education, but also nutrition investments play a role
- In these countries, financial constraints make it difficult to invest, especially for poorer households

→ 20% of children under age 5 have extremely low height-for-age

→ 53% of children unable to understand a simple text by age 10

→ In Indonesia, 43% cannot perform one-digit multiplication by the end of 3rd grade

Motivation

Development policies can be used to increase children's skills

$\Downarrow$

Parents play important role as they decide on investment inputs for their children

$\Downarrow$

Understanding parental investment decisions is fundamental to design effective policies

$\Rightarrow$ I quantitatively evaluate effects of different policies taking into account parents' decisions

This paper

1. I model parental investment decisions in low/middle income country setting
   - Parents get utility from their children's skills and consumption
   - They decide on investment in children: nutrition and schooling expenditure
     → subject to financial constraints
   - Children's skill dynamically accumulate in multi-period skill production function
     → parental characteristics influence skill production

LMIC Indonesia data literature

This paper

2. I structurally estimate the model using panel data from Indonesia (IFLS, 1993-2014)
   - Long panel

     → childhood stages modelled: early childhood to adulthood
   - Measurements of schooling expenditure and nutrition (food diversity)
   - Measurements of skills (math, logic and language test scores)

     → allows to identify cognitive skills
3. I simulate the impact of policies: nutrition and schooling subsidies, and cash transfers

LMIC Indonesia data

Contribution to the literature

- Role of nutrition in child development

  Hoddinott et al. (2008), Belot and James (2011), Sánchez (2017), Lee et al. (2018), Aurino et al. (2020), Bailey et al. (2020), Behrman et al. (2020), Filmer et al. (2021)

  → I use a structural model which allows me to include parents' investment decisions and reactions to policies

  → I can estimate the complementarity of schooling and nutrition

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- Dynamic models of skill formation

  Cunha and Heckman (2008), Cunha et al. (2010), Villa (2017), Attanasio et al. (2017, 2020a,b)

  → I model endogeneous parental investment choices

Contribution to the literature

- Models of skill formation with endogenous parental choices

  Todd and Wolpin (2007), Bernal (2008), Del Boca et al. (2014), Daruich (2018), Lee and Seshadri (2019), Caucutt et al. (2020)

  → I model nutrition as investment input

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  → I model nutrition as investment input

- Evaluations of child development policies in low- and middle-income countries

  Duflo (2001), Todd and Wolpin (2006), Macours et al. (2012), Krishnamurthy et al. (2017), Kaul (2018), Cahyadi et al. (2020), Ashraf et al. (2020), Bobba et al. (2021)

  → I conduct ex-ante policy evaluation and test for dynamic complementaries

Data: Indonesian family life survey

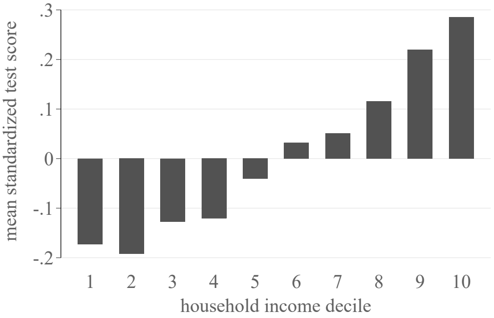
- Panel survey with 7,200 households (1993, 1997, 2000, 2007, 2014)
- Representative of 83% of Indonesian population
- Data on children's outcomes: height, weight, math, logic and language test scores
- Investment measures:
  - Food groups consumed (staples, proteins, fruits, vegetables, dairy)
  - Schooling expenditure (fees, books, transport, special courses, uniform, food)

→ 43.6% of population lives with less than \$2.15 a day in 2000

→ 42.4% of children under age 5 display extremely low height-for-age in 2000

data

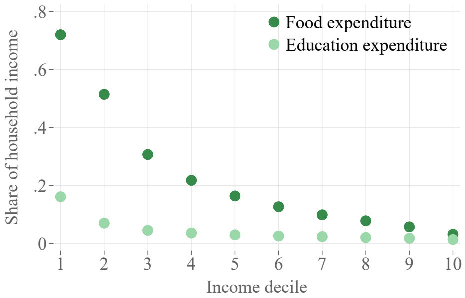
Figure: Mean standardized test scores by household income decile in Indonesia



→ Persistent skill gap by income

investments by education

Figure: Investments as shares of household income



Note: Data from Indonesian family life survey. Household income adjusted by household size.

→ Higher income households spend lower share of income on investments and have lower share of nutrition investments

Model set-up:

- 3 childhood stages $t \in \{1, 2, 3\}$
- Parents divided into 3 education groups

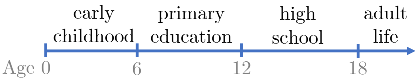
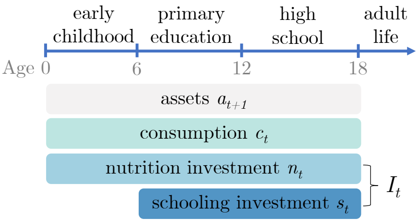


Figure: Model stages

details

Model set-up:

- 3 childhood stages $t \in \{1, 2, 3\}$
- Parents divided into 3 education groups
- Choices: consumption, assets and child investments
- Investments I_t are composed of nutrition n_t and schooling s_t



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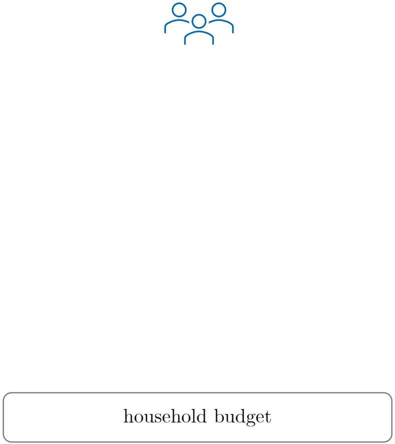

Figure: Exemplary model period

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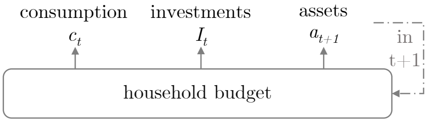

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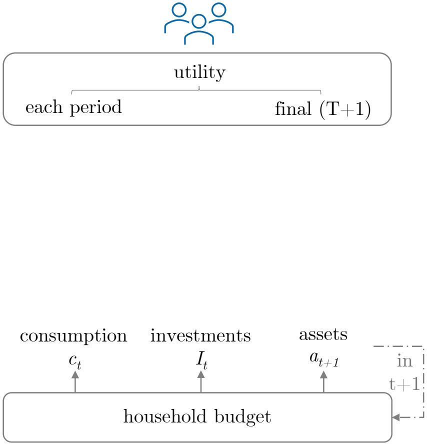

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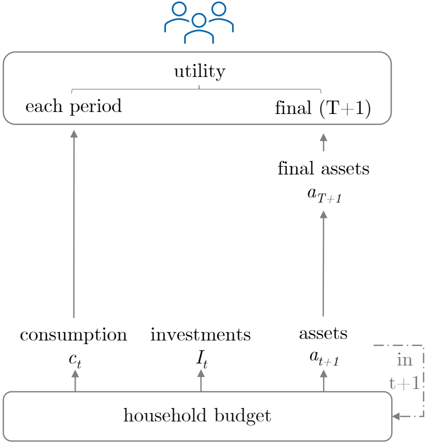

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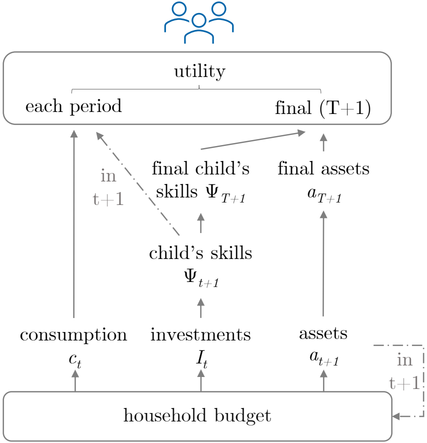

Figure: Exemplary model period

details

Socioeconomic status influences choices via:

- preferences for skills
- household income and assets
- skill formation (differences in productivity)

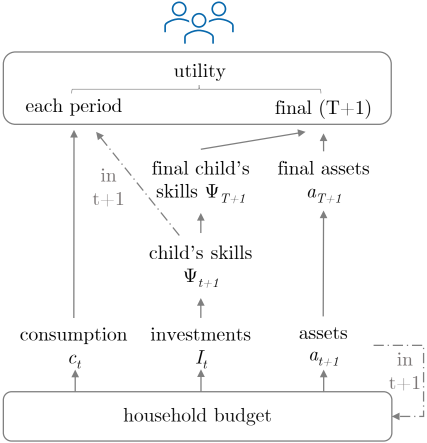

Figure: Exemplary model period

details

Skill formation:

- investments:
  nutrition + schooling
  → substitutes or complements?
- future skills:
  investments + skills
  → timing
- productivity of inputs varies by parental education and parenting skill type

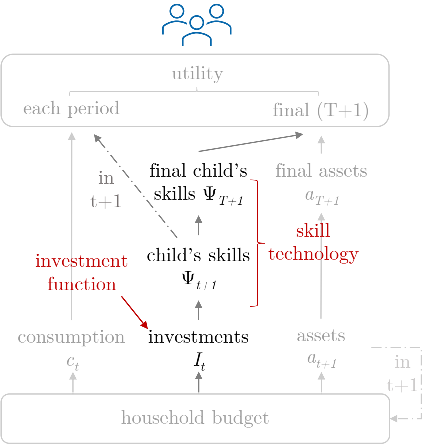

Figure: Exemplary model period

details

Overview estimation

Parameters	Strategy
Outside of the model:	
Annual discount factor	Dutu (2016): 0.98
Unobserved parenting skill types	Bonhomme et al. (2022): k-means clustering
Household income	OLS prediction
Structural model:	
Investment function parameters	Estimation by joint GMM
Skill production function parameters	→ Inv → HC
Preference parameters	Simulated method of moments

model types types results

Estimation of dynamic structural model

Step 1: Parameters of children's skill formation (generalized method of moments)

- Regional and time variation in food prices: substitutability of investments
- Variation in investment levels and skills across periods and children: impact of parental characteristics and investment by period
- Two measures for cognitive skills: accounting for measurement error

results summary details fit

Estimation of dynamic structural model

Step 1: Parameters of children's skill formation (generalized method of moments)

- Regional and time variation in food prices: substitutability of investments
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Step 2: Preference parameters (simulated method of moments)

- Estimated using model solution for investments and assets

results summary details fit

Summary of estimation results

1. How does higher parental education impact skill development?
   - Parents produce higher future skills with same level of inputs
   - They are more effective in using schooling inputs
     → Spend larger share of their investments on schooling
   - They value cognitive skills less
     → Parents mainly constrained by budget and productivity
2. Are nutrition and schooling complements or substitutes?
   - Complements, with higher complementarity in high school
     → parents react to price decreases with increasing both inputs

estimation fit decomposition

Policy scenarios

1. Nutrition price subsidy (20%)
2. Schooling price subsidy (99%)
3. Unconditional cash transfer (3% of mean income)

→ Implemented for lowest 20% of income distribution

→ Implemented at primary and high school stage

→ Simulated to be cost-equivalent

summary results | table | inequality | combinations

Policy scenarios - results

1. Nutrition price subsidy (20%) ↑ **0.04 SD**
2. Schooling price subsidy (99%) ↑ 0.03 SD
3. Unconditional cash transfer (3% of mean income) ↑↓ negligible effects

→ Implemented for lowest 20% of income distribution

→ Implemented at primary and high school stage

→ Simulated to be cost-equivalent

summary results | table | inequality | combinations

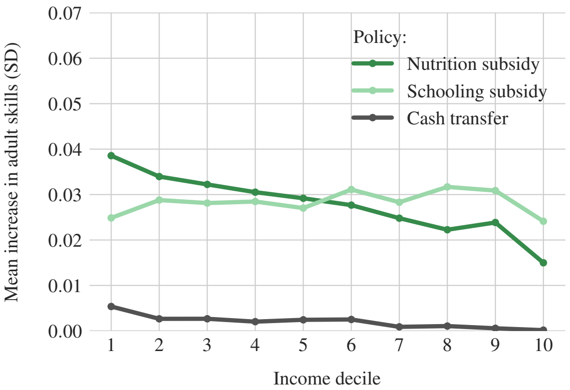
Inequality reduction of policies

Can nutrition subsidies decrease inequality? If so, why?

→ Simulate polices for each household income decile:

1. Nutrition price subsidy (20%)
2. Schooling price subsidy (99%)
3. Unconditional cash transfer (3% of mean income of lowest 20%)

Figure: Policy impacts by income decile



→ Effect of cash transfer and nutrition subsidy decreases with income

→ Nutrition subsidy most effective to reduce skill gap

investments table

Mechanism

- Nutrition subsidies can reduce inequality

Low income parents spend higher share on nutrition investments
(lower productivity of schooling)

$\Downarrow$

React stronger to nutrition price changes

$\Downarrow$

Increase both inputs (complements)

$\Downarrow$

Adult cognitive skills $\uparrow$

- More cost-effective to implement nutrition subsidy alone instead of splitting costs and combine policies

details combinations

Recap

- In this paper:
  - I estimate a dynamic structural model of skill formation with endogenous investment decisions in schooling and nutrition
  - I decompose the skill gap by socioeconomic status in Indonesia
  - I simulate long-run impacts of cash transfers, nutrition and schooling subsidies on cognitive skills
- Main finding:
  - Nutrition subsidy: $\uparrow$ 0.04 SD in adult skills
  - Schooling subsidy: $\uparrow$ 0.03 SD in adult skills
  - Nutrition subsidies more cost-effective than splitting the budget into two policies

Thank you!

If you have any further feedback, please feel free to contact me!

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Appendix

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Parents' investments influencing cognitive skill development

- Nutrition

  Hoddinott et al. (2008), Belot and James (2011), Sánchez (2017), Galasso et al. (2019), Aurino et al. (2020), Behrman et al. (2020)

- Education

  Todd and Wolpin (2006), Doepke and Zilibotti (2019), Dizon-Ross (2019), Ashraf et al. (2020), Behrman et al. (2021) Beuermann et al. (2022)

→ Interaction between investment inputs matters

→ Parents' reaction to policy important for long run effects

→ Reactions might vary by socioeconomic status influencing inequality impacts

back

Figure: Mean education expenditure

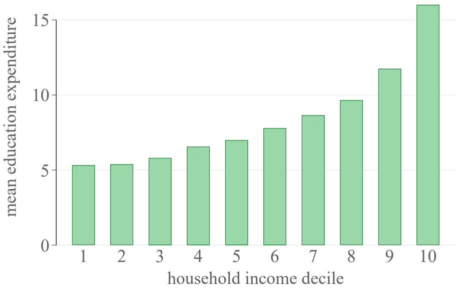
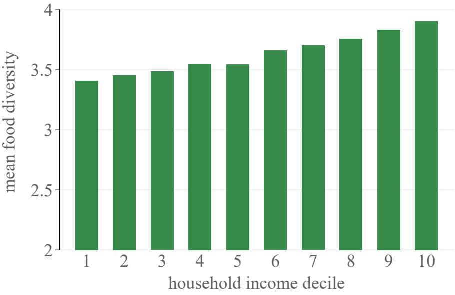


Figure: Mean food diversity



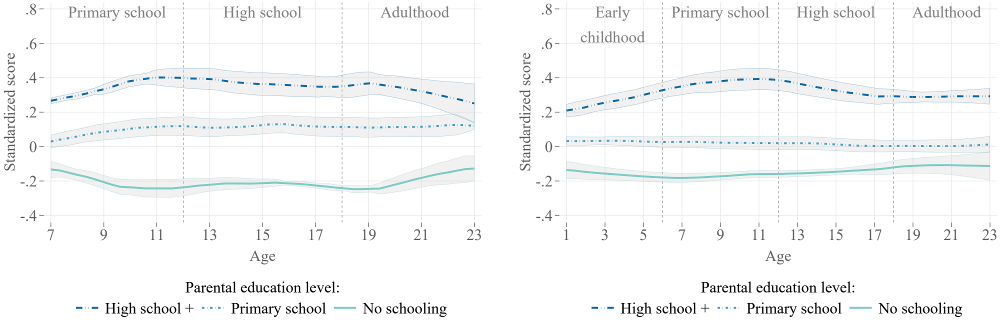
Note: Data from Indonesian family life survey.

Note: Diversity equals number of food groups consumed.

→ within-country socioeconomic gradient in investments

back shares

Figure: Children outcomes by parental education over age in Indonesia



(a) Test score (b) Height

Note: Corresponding skills are fitted with local mean smoothing by age and parental education groups. Parental education groups correspond to the average education of both parents. Confidence intervals displayed are at 95% level. Scores are standardized by age to have mean 0 and sd of 1.

→ persistent skill gap opening early in life in Indonesia

back

Skill production function

$$\Psi_{t+1} = \theta_t(Z_{\theta,t}) I_t^{\delta_{1,t}} \Psi_t^{\delta_{2,t}}$$

$\delta_{t,1}$: impact of investments I_t on future skills Ψ_{t+1}

$\delta_{t,2}$: impact of current skills Ψ_t on future skills Ψ_{t+1}

→ policy implications: differential returns from higher investments/skills by childhood period

$\theta_t(Z_{\theta,t}) = \exp(Z'_{\theta,t}\phi_{\theta,t})$: total factor productivity

→ effectiveness of converting given level of skills and investments into future skills

→ depends on characteristics $Z_{\theta,t}$ (parental education e, age)

estimation results outline

Investment function

$$I_t = [a_{s,t}(Z_{s,t}, \eta) s_t^{\rho_t} + n_t^{\rho_t}]^{\frac{1}{\rho_t}}$$

ρ_t: substitution parameter for investment inputs nutrition n_t and schooling s_t

→ complements or substitutes

→ policy implications: different reactions to price subsidies

$a_{s,t}(Z_{s,t}, \eta) = \exp(Z'_{s,t}\phi_{s,t} + \eta'\phi_{\eta,t})$: relative productivity of schooling s_t

→ determines share spend on schooling vs. nutrition for given level of investments

→ depends on characteristics $Z_{s,t}$ (e.g. parental education e) and parenting skill type η

estimation results types outline

Maximisation problem

$$V_t(a_t, y_t, \Pi_t, \Psi_t, Z_t, \eta, e) = \max_{c_t, n_t, s_t, a_{t+1}} \ln(c_t) + \alpha_e \ln(\Psi_t) +$$
$$+ \beta V_{t+1}(a_{t+1}, y_{t+1}, \Pi_{t+1}, \Psi_{t+1}, Z_{t+1}, \eta, e),$$

$$\text{s.t} \quad c_t + p_{n,t} n_t + p_{s,t} s_t + a_{t+1} = (1+r)a_t + y_t$$
$$a_{t+1} \geq a_{min}$$
$$\text{with: } V_{T+1}(\Psi_{T+1}, a_{T+1}) = \alpha_e \gamma \ln(\Psi_{T+1}) + \zeta \ln(a_{T+1})$$
$$y_t = f_t(Z_t, \eta) + \epsilon_{y,t}$$

a_t: assets, y_t: household income, Π_t: price vector for investments, Ψ_t: child's skills, Z_t: household characteristics, c_t: consumption, n_t: nutrition, , s_t: schooling, $p_{n,t}$: price nutrition, $p_{s,t}$: price schooling, e: parental education

prices estimation outline

Estimation investment function

$$I_t = [a_{s,t}(Z_{s,t}, \eta) s_t^{\rho_t} + n_t^{\rho_t}]^{\frac{1}{\rho_t}}, \quad \rho_t < 1$$

- derive relative demand ratios
- exploit variation in food prices for substitution parameter

Relative demands moments for nutrition and schooling:

$$\underbrace{\ln(\frac{p_{n,t} n_t}{p_{s,t} s_t})}_{\substack{\text{investment} \\ \text{expenditure} \\ \text{ratio}}} = \frac{1}{\rho_t - 1} \underbrace{Z'_{s,t} \phi_{s,t}}_{\substack{\text{productivity} \\ \text{(by education)}}} + \frac{1}{\rho_t - 1} \underbrace{\eta' \phi_{\eta,t}}_{\substack{\text{unobserved} \\ \text{parenting} \\ \text{skills}}} + \frac{\rho_t}{\rho_t - 1} \underbrace{\ln(\frac{p_{n,t}}{p_{s,t}})}_{\substack{\text{price} \\ \text{ratio}}}$$

with: $a_{s,t}(Z_{s,t}, \eta) = \exp(Z'_{s,t} \phi_{s,t} + \eta' \phi_{\eta,t})$

prices estimation details results

Table: Estimation results for investment parameters

	Primary school		High school	
Investment elasticity:				
ρ_t	-3.75	(0.86)***	-11.38	(5.11)**
Implied elasticity	0.21		0.08	
Schooling investment productivity $\phi_{s,t}$*:*				
Constant	-3.68	(0.51)***	-42.17	(16.55)**
Mother primary	1.10	(0.25)***	3.06	(1.32)**
Mother high	1.87	(0.39)***	5.04	(2.15)**
Father primary	0.09	(0.16)	0.63	(0.47)
Father high	-0.08	(0.19)	0.51	(0.50)
N	27,366			

Note: Standard errors in parenthesis, *** p<0.01, ** p<0.05, * p<0.1.

→ nutrition and schooling are complements, higher complementarity in high school

→ mothers with higher education invest more in schooling

Estimation skill production function

$$\Psi_{t+1} = \theta_t(Z_{\theta,t}) {I_t}^{\delta_{1,t}} {\Psi_t}^{\delta_{2,t}}$$

- measures $S_{j,t}$ with $j \in \{1,2\}$ for skills Ψ_t: height/weight (period 1) and math/logic test scores (after)
- measurement system following Cunha et al. (2010) and Caucutt et al. (2020):

$$S_{j,t} = \lambda_{j,t} \ln(\Psi_t) + \epsilon_{j,t}$$

Skill formation moments:

$$\frac{1}{\lambda_{j,t+1}} S_{j,t+1} - (\underbrace{Z'_{\theta,t}\phi_{\theta,t}}_{\substack{\text{productivity} \\ \text{(by education)}}} + \delta_{1,t} \ln(I_t) + \delta_{2,t} \frac{1}{\lambda_{j,t}} S_{j,t}) = 0, \text{ with } \theta_t(Z_{\theta,t}) = \exp(Z'_{\theta,t}\phi_{\theta,t})$$

estimation results factor loadings

Factor loadings

$$S_{j,t} = \lambda_{j,t} \ln(\Psi_t) + \epsilon_{j,t}$$

→ normalization like Caucutt et al. (2020): $\lambda_{1,t} = 1$

→ exploit covariance structure for $\lambda_{2,t}$ as in Cunha et al. (2010):

$$\lambda_{2,t} = \frac{Cov(S_{1,t}, S_{1,t+1})}{Cov(S_{2,t}, S_{1,t+1})} \quad \text{and} \quad \lambda_{2,t+1} = \frac{Cov(S_{1,t}, S_{1,t+1})}{Cov(S_{1,t}, S_{2,t+1})}$$

Factor loading moments:

$$\mathrm{E}[(S_{1,t+1} - \lambda_{2,t+1} S_{2,t+1}) S_{ts_1,t}] = 0 \quad \text{and} \quad \mathrm{E}[(S_{1,t} S - \lambda_{2,t} S_{2,t}) S_{1,t+1}] = 0$$

estimation skill estimation

Table: Estimation results for human capital parameters

	Early childhood		Primary school		High school	
Human capital parameters:						
$\delta_{1,t}$ (investment)	0.28	$(0.06)^{***}$	0.16	$(0.05)^{***}$	0.18	$(0.03)^{***}$
$\delta_{2,t}$ (skills)	0.10	$(0.02)^{***}$	0.19	$(0.02)^{***}$	0.22	$(0.01)^{***}$
Total factor productivity $\phi_{\theta,t}$:						
Constant	-0.73	$(0.08)^{***}$	-0.02	(0.12)	-0.22	$(0.09)^{**}$
Mother primary	0.02	(0.04)	0.06	(0.04)	0.05	$(0.02)^{**}$
Mother high	0.22	$(0.03)^{***}$	0.25	$(0.04)^{***}$	0.16	$(0.03)^{***}$
Father primary	0.02	(0.04)	0.13	$(0.04)^{***}$	0.03	(0.03)
Father high	0.11	$(0.03)^{***}$	0.07	$(0.04)^{*}$	0.11	$(0.03)^{***}$
N	27,366					

Note: Standard errors in parenthesis, *** p<0.01, ** p<0.05, * p<0.1.

→ investments highest impact in early childhood + overall low persistence in skills

→ parents with high school education lead to high factor productivity

Table: Calibrated preference parameters

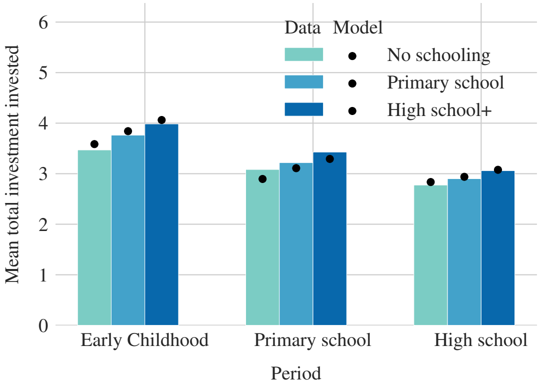
	Parental education:		
	No schooling	Primary school	High school+
For current skills:			
α_e	2.38	1.62	0.98
For final skills:			
γ_e	1.40	1.38	1.45
For final assets:			
ζ	9.98	9.98	9.98

Note: Calibration method used: simulated methods of moments. Moments targeted were investments by parental education and by childhood period.

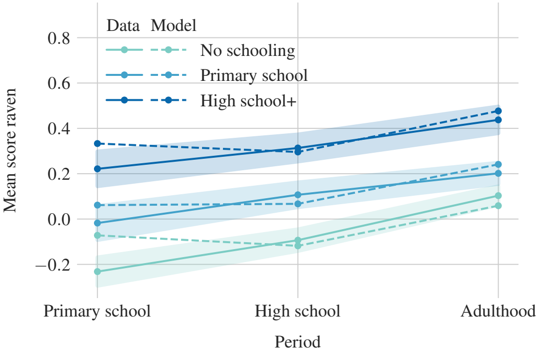
→ parents with lower education value current skills higher

→ similar additional valuation for final skills

Figure: Model fit



(a) Targeted moments: investments



(b) Untargeted moments: skills

back

Price for education

- $p_{s,t} = 1$ for all households
- s_t is then schooling expenditure observed in the data (fees, registration, books)

max. problem estimation

Price for food

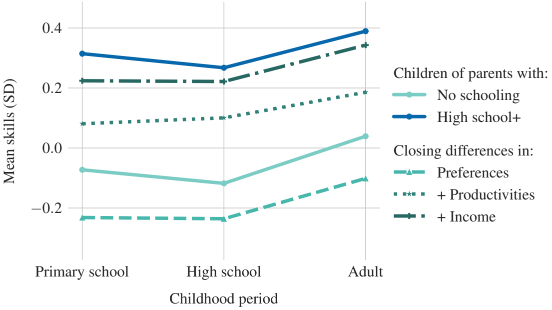
- median price for 1 kg of grains/vegetables and meat for each locality m
- adjusted for fraction median amount of each food group purchased by households:
  - $fp_{m,t} = (0.43 price_{grain,m,t} + 0.14 price_{veg,m,t} + 0.43 price_{meat,m,t})$
- to get yearly price, I use household expenditure divided by estimated food price, adjust it by household equivalence scale and calculate kg consumption for children kg_{cons}
- food price $p_{g,t} = fp_{m,t} \times kg_{cons}$

max. problem estimation

Skill gap simulations

Main drivers:

- preference differences (−)
- technology differences (+)
- income differences (+)



back summary

Table: Policy counterfactuals - investment and skill change

	Cash transfer	Nutrition subsidy	Schooling subsidy
Change in mean adult skills (SD):			
All targeted	0.00	0.04	0.03
Change in mean investments (%):			
Investments	1.65	16.29	8.87
Nutrition	1.57	15.92	6.80
Schooling	1.46	18.44	90.54
Costs in 100,000 rupees per child:			
Per 0.01 SD increase	1676.02	210.28	288.96
Total amount	7.60	7.60	7.60

Note: Policies are designed to have the same costs (in 100,000 rupees ∼ \$7), resulting in a 3% cash transfer, 20% nutrition subsidy and 99% schooling subsidy.

→ Nutrition subsidy most effective followed by schooling subsidy

scenarios

Table: Policy combination counterfactuals - investment and skill change

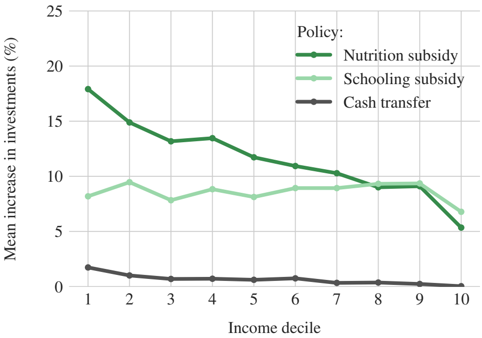
	Cash+ nutrition	Cash+ schooling	Nutrition+ schooling	Nutrition subsidy
Change in mean adult skills (SD):				
All targeted	0.04	0.03	0.06	0.10
Change in mean investments (%):				
Investments	17.55	10.51	26.49	48.17
Nutrition	17.09	8.37	23.94	47.26
Schooling	20.16	93.30	131.66	63.61
Costs in 100,000 rupees per child:				
Per 0.01 SD increase	387.52	483.49	267.80	157.45
Total amount	15.25	15.31	17.31	15.25

Note: Costs are expressed in 100,000 rupees ($\sim$ \$7), combined policies are a 3% cash transfer, 20% nutrition subsidy and 99% schooling subsidy. The nutrition subsidy is 51% to be cost-equivalent to the cheapest combination.

$\rightarrow$ Nutrition subsidy alone more effective

back

Figure: Policy impacts on investment by income decile



→ decrease in investments with nutrition subsidy, stable with schooling

→ period dynamics and higher productivity lead to higher impact of schooling subsidy for upper income distribution

back

Policy scenarios - combinations

Is splitting the budget and combining policies more effective than a nutrition subsidy alone?

Simulation of policy combinations:

1. Nutrition price subsidy + cash transfer
2. Schooling price subsidy + cash transfer
3. Nutrition + schooling price subsidy
4. Nutrition subsidy alone (benchmark)

Table: Combinations of policies and their effectiveness

	Policy combinations			
	1	2	3	4
Nutrition subsidy (20%)	✓		✓	
Schooling subsidy (99%)		✓	✓	
Cash transfer (3%)	✓	✓		
Nutrition subsidy (51%)				✓
Impact on adult skills (in SD)	0.04	0.03	0.07	**0.10**
Costs (in 100,000 rupees)	15.36	15.39	17.42	15.36

Note: Costs are expressed in 100,000 rupees per child ($\sim$ \$7), combined policies are a cash transfer (3% of mean income), nutrition subsidy (20%) and schooling subsidy (99%). The benchmark nutrition subsidy is 51% to be cost-equivalent to the cheapest combination.

→ Nutrition subsidy alone is more effective

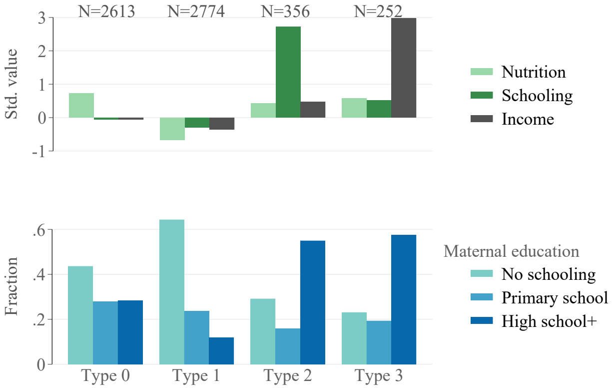
combinations | summary

Unobserved parenting skills

- K-means clustering to discretize parenting types η (Bonhomme et al. (2022))
- Assumption: moments of same type converge on the long run
- Standardized life-cycle moments:
  - Average schooling investments by household
  - Average nutrition investments by household
  - Household income
- Number of types chosen by Ellbow/silhouette criteria (4 types)

estimation results graph

Figure: Characteristics of parenting types η (investments/resources and education)



Note: Nutrition is food groups consumed, schooling education expenditure and income annual household income (life-time averages by parenting pair).

→ Variation in parenting types across education and within education categories

model estimation table